ELEVENTH ANNUAL REPORT

OF THE

UNITED STATES

GEOLOGICAL AND GEOGRAPHICAL SURVEY

OF

THE TERRITORIES,

EMBRACING

IDAHO AND WYOMING,

BEING A REPORT OF PROGRESS OF THE EXPLORATION FOR THE YEAR

1877.

BY F. V. HAYDEN,
UNITED STATES GEOLOGIST.

CONDUCTED UNDER THE AUTHORITY OF THE
SECRETARY OF THE INTERIOR.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1879.

TABLE OF CONTENTS.

PART II.—TOPOGRAPHY.

LIST OF ILLUSTRATIONS.

PALEONTOLOGY.

ACCOMPANYING C. A. WHITE'S REPORT.

GEOLOGY AND TOPOGRAPHY.

[Maps, sections, views, &c.]

ACCOMPANYING F. M. ENDLICH'S REPORT.

ACCOMPANYING O. ST. JOHN'S REPORT.

The collation of the illustrations of this Report is therefore: Pll. I–VI, 1–10, VII–LXVI, LXVI*a*, LXVII–LXXV, LXXVa, LXXVI, 1 map.

Plates 1–10 have each an unpaged explanatory leaf, additional to the regular pagination of the volume.

LETTER TO THE SECRETARY.

OFFICE OF THE UNITED STATES GEOLOGICAL AND
GEOGRAPHICAL SURVEY OF THE TERRITORIES,
Washington, D. C., December 1, 1878.

SIR: I have the honor to submit the following report of the operations of the Survey under my charge, both in the field and in the office, during the year 1877.*

On the completion of the work in Colorado in 1876, it was decided that it should continue northward into Idaho and Wyoming Territories. The belt of country along the fortieth parallel, including the Union Pacific Railroad, having been explored in detail by the Survey of the Fortieth Parallel under Clarence King, it was deemed best to commence at the northern boundary of that work and continue northward and westward.

The survey was divided into five parties for field, geological, and topographical work, besides several others for special investigation. The following notes present the salient features of the summer's work:

PRIMARY TRIANGULATION.

The primary triangulation party in charge of Mr. A. D. Wilson, chief Topographer of the Survey, took the field from Rawlins Springs, Wyo. Near this place a base-line was carefully measured and from this a network of triangles was extended to the north and west. After completing the work in the vicinity of Rawlins, the party marched northward, making stations on Seminoe and Whiskey Peaks, and thence traveled westward to Yellow Butte, where another station was located. From this point the work was carried to the Wind River Range. Three stations were made on the more prominent points of this range, with much difficulty, owing to the great quantities of snow found in these mountains during the month of June—the time the party was working there.

Continuing the work northward and westward, stations were made on the Grosventre and Wyoming Ranges and on Caribou Mountain and Mount Putnam near Fort Hall. After refitting at the latter place, the party marched south viâ Soda Springs to the valley of Bear Lake, where

*A portion of this introduction was printed in the Preliminary Report of the Field Work of the Survey for 1877 (Ann. Rep. Secretary of the Interior for 1877, pp. 755–787), and also in the Annual Report of the Smithsonian Institution for 1877. It remains nearly as it was written over one year ago.

another base-line was measured and connected with the work as brought forward from the Rawlins base.

After occupying Mount Preuss, Soda, Paris, and North Logan Peaks, the party marched to Evanston, where connection was effected with the astronomical station made at this point by the boundary survey of Wyoming. Stations were also made on Medicine Butte and Ogden Peak, thus connecting with the primary triangulation of the fortieth parallel survey. From Evanston the party moved eastward, occupying Pilot and Black Buttes, again visiting Separation Peak near Rawlins, thus bringing the work back to the point of beginning, where the party was disbanded and the train sent into winter quarters at Cheyenne.

Mr. Wilson has finished the preliminary computations of his work, and a chart showing the results has been published. Twenty-six points were occupied, while many others were located by foresights, among them the Grand Téton and Washakie Needles.

The triangulation covered an area of about 28,000 square miles, extending from longitude 107° to 112° and between north latitude 41° 10′ and 43° 50′.

Stone monuments were built on all occupied points for future reference, and when the final computations are made, the latitude and longitude of all these points will be given, with azimuths and distances between the points.

TOPOGRAPHY.

The topographical field-work of the past season was carried on by three parties, to each of which a definite area was assigned to be surveyed. These areas were approximately in the form of rectangles, limited by meridians and parallels of latitude. Each of them contained about 11,000 square miles. That assigned to the Téton division, in charge of Mr. G. R. Bechler, lay between the meridians of 109° 30′ and 112° and the parallels 43° and 44° 15′. This area comprises nearly all the country about the sources of Snake River, including the very rugged range of the Téton Mountains and the northern half of the Wind River Mountains. From the character of the country, being nearly all mountainous, and much obstructed by living and fallen timber, work was necessarily slow, yet Mr. Bechler succeeded in surveying nearly 6,000 square miles up to the early part of September, when he was obliged to stop work and leave the country, owing to the proximity of Joseph's band of hostile Indians. About one-third of the area surveyed by this division lies south of the Snake and west of Salt River. The remainder includes the greater part of the most rugged mountains, among them the Tétons and a portion of the Wind River Range.

That portion of the district lying south of Snake River consists of the northern ends of two mountain-ranges, known as the Blackfoot and Caribou Ranges, with their adjacent valleys. These ranges have the normal trend; are here scarcely high enough (6,000 to 8,000 feet above

sea-level) to be dignified with the name of mountains, and are bare of timber and grass-covered. All this section is fine grazing land, and in the valleys are large areas of arable land.

North of the Snake are several fine valleys, well watered from the snow-fields of the high mountains, among which are Pierre's and Jackson's Holes; but the mass of the country is made up of mountains. As a rule, the valleys are narrow, mere cañons in very many cases. The mountains are everywhere heavily timbered with pine and spruce.

During the season, Mr. Bechler occupied 60 stations, and measured 7,340 horizontal and 5,700 vertical angles.

The area assigned to the Green River division, in charge of Mr. Henry Gannett, lay between the meridians of 109° 30′ and 112° 00′ and the parallels of latitude of 41° 45′ and 43° 00′, being directly south of that of the Téton division. This district includes the northern half of the Green River Basin, nearly all the drainage area of the Bear, and several large branches of the Snake, comprising portions of the three Territories of Wyoming, Idaho, and Utah. The country being especially well adapted to this class of surveying, work was pushed very rapidly, so that, after finishing his district, Mr. Gannett was enabled to carry the work westward over the valleys of the Portneuf and Malade, with their bounding ranges.

With the exception of the Green River Basin, which is a broad, flat expanse of sage and grass, the country consists of a succession of parallel ranges of mountains, with the normal Rocky Mountain trend, separated by broad valleys. The valleys are fertile and easily irrigated, while everywhere there is a bountiful supply of water. The average elevation of these valleys is from 4,000 to 6,000 feet, while the mountains rise to heights ranging from 8,000 to 11,000 feet.

The lower mountain-ranges are grass-covered, while the higher ones are well timbered, in some cases even densely timbered, with heavy spruce and pine. The area of irrigable land is, by a rough estimate, ten per cent. of the district, while at least three-fourths of it is suitable for grazing. In surveying this area, Mr. Gannett made 347 stations of all grades of importance, building monuments on 53 of the principal ones for future reference by the land surveys, or other purposes.

The district assigned to the Sweetwater division, under Mr. George B. Chittenden, lay between meridians 107° 00′ and 109° 30′ and parallels 41° 45′ and 43° 00′, being east of that last described. It includes the southern half of the Wind River Range, the valleys of Wind River and the Sweetwater, with the Sweetwater Mountains and the desert-like plateaus about the continental divide south of the latter. Of this area nearly all or between 10,000 and 11,000 square miles were surveyed. Of this district, a rough estimate makes five-eighths desert country, two-eighths mountainous, of value only for its timber, or, hypothetically, for its mineral contents, and one-eighth only valuable as pasture or agricultural land. In surveying this area Mr. Chittenden made nearly 200

stations. Between 80 and 90 of these were marked permanently by stone monuments for future reference.

As heretofore, attention has been paid to the economic value of the land surveyed. Map notes and sketches indicate the extent of land suitably situated for irrigation, and as all streams of any magnitude are gauged, and their slopes measured, the data for estimates of the amount of arable land are at hand. Areas of pasture and timber lands are also noted.

During the whole season, of four months' duration, the weather was exceptionally favorable for the prosecution of the work; scarcely a day was lost from bad weather by any of the parties.

The total area surveyed during the season, and to be mapped during the winter, was about 29,000 square miles, a very considerable addition to our knowledge of the Western country.

In succeeding years the work is to be extended toward the north, east, and west.

GEOLOGY.

The geological field-work of the survey for 1877 was assigned to Dr. F. M. Endlich, Prof. Orestes St. John, and Dr. A. C. Peale, in the Sweetwater, Téton, and Green River districts, respectively. Many interesting geological facts were observed, which are given in detail in this report.

The Sweetwater district comprised a well-diversified country. The eastern portion of the Green River Basin was found to be underlaid with Tertiary formations, with isolated volcanic eruptions at several points. The prevailing westerly winds of the region have resulted in the formation of sand dunes wherever the configuration of the country has offered an obstacle to the progress of the sand that is formed from the readily disintegrating Tertiary sandstones. On the eastern side of the Wind River Mountains a full series of the sedimentary formations was noted, beginning with the Silurian, and numerous stratigraphical phenomena were observed and studied with a view to the determination of the age of the mountain-range.

Camp Stambaugh, at the south end of the range, is located within the area of the oldest metamorphic rocks of the district. In these rocks gold has been found in varying quantities for the last ten years, and, at one time, the region was the scene of considerable mining excitement.

The western side of the Wind River Mountains was found to be very interesting on account of the remains of enormous ancient glaciers. Moraines, covering many square miles, and often a thousand feet in thickness, extend downward through narrow valleys that now contain rushing streams. Striation, grooving, and mirror-like polish of rock *in situ*, denote the course taken by the moving ice-fields that have left these marks of their former existence. From all indications, the cessation of glacial activity must have occurred within a comparatively recent time.

Scarcely any vegetation has sprung up on the light glacial soil, and the characteristic distribution of erratic material bears every evidence of "freshness."

All along the Sweetwater River the characteristic Sweetwater group of the Tertiary was found, continuing northward to the hills opposite Seminoe Pass. These hills were found to be projections of granite that during the Tertiary epoch, and probably long before, existed as islands in a widely extended sea.

On the south side of the Sweetwater, in the Seminoe Hills, the older sedimentary formations were noted. In the region between the Seminoe Hills and Rawlins, on the Union Pacific Railroad, an interesting group of mud-springs, analogous to the mud-puffs of the Geyser region, were seen. About four hundred of these curious springs were found and examined.

After finishing his work with the field-party, Dr. Endlich visited the coal-mines near Evanston, Wyo., to examine the coal-bearing rocks of that region.

The Green River district lies directly west of the Sweetwater district. With the exception of a small area of granite, along the southwestern side of the Wind River Mountains, and some basaltic flows in the northwestern portion of the district, the rocks are sedimentary. The Green River Basin was the first area surveyed. The prevailing formation was found to be the Green River group of the Tertiary, underlaid by the Wahsatch. Toward the south, buttes of the Bridger clays rest on the Green River marls and sandstones. They are the northern outliers of the extensive Bridger areas found farther southward.

On the northeast, the Tertiary beds rest on the granites of the Wind River Mountains, the line of junction being considerably obscured by morainal material. One of the most interesting points noted in the Green River Basin was on its west side, where the Wahsatch Tertiary is seen resting uncomformably on Jurassic and Cretaceous strata. At one point Carboniferous fossils were obtained from bowlders of limestone found in a conglomerate in the Wahsatch group. These were derived without doubt from the Carboniferous limestones of the mountains that stand a short distance to the westward, and which must once have formed a portion of the shore-line of the lake filling the Green River Basin.

An arm of this Tertiary lake extended up Ham's Fork of the Green River, where Green River and Wahsatch beds are found in horizontal position. In the Green River shales, at several localities, good collections of fossil fish and insects were found, among which were many new species.

The region of the Blackfoot River, in the northwestern part of the district, is covered in all its lowest portions with flows of basalt which had their origin in craters that still show between the Blackfoot, Bear, and Portneuf Rivers. The pouring out of this basalt must have occurred

either during or just prior to the present period, as there has been but little if any change in the surface since the eruption. On the Portneuf River a narrow tongue of basalt extends almost to Snake River Valley. The surface of this basalt slopes somewhat, but not so much as the present bed of the Portneuf. The lower valley of the Portneuf is interesting from the fact that it is probably one of the ancient outlets of the great lake that once filled the Salt Lake Basin and extended across into Cache Valley. In Cache Valley and Malade Valley, modern Tertiary deposits are found jutting against the mountains, and in the central portions of the valleys they seem to pass gradually into the more modern deposits.

The interesting soda-springs at the bend of Bear River were carefully examined.

Although the area surveyed by the Green River division was large, comprising about 13,000 square miles, large collections of fossils (many of them new) were made. Notes were obtained for the preparation of a geological map of the area, and data collected for the elucidation of many interesting problems in relation to the age of the mountains.

Coal-outcrops were noted at a number of localities, on some of the branches of the Upper Bear River and of Green River. The famous salt-works on a branch of Salt River were also examined.

Professor St. John reports the Téton district to be one of great interest. He found extensive areas covered with rocks of igneous origin, basalts, and trachytes.

The Snake River plains are everywhere floored with basaltic rocks. They extend up the valley of the Snake as far as the lower basin, where they are succeeded by other volcanics, mainly trachytes. The latter are observed inclining at greater or less angles and appear to be more ancient than the basalts. The Blackfoot Valley and the valley depressions between the Blackfoot Mountains and the Caribou Range are floored with basalts in every way similar to those occurring in the Snake River plains. These extend southward into Dr. Peale's district.

Rhyolitic products were found at a few localities. In one instance the eruptive matter appears as a dike in the crest of a low, short ridge between the Blackfoot and Caribou Ranges, its eruption having tilted the sedimentary deposits into an anticlinal ridge.

In Caribou Mountain, also, interesting phenomena were observed. The mountain is a monoclinal ridge, made up of sedimentaries, between whose strata the igneous material is intruded, appearing from a distance like veritable beds of deposition, while the bulk of the west portion of the mountain appears to consist of an enormous mass of eruptive matter thrust up from below. This mountain would therefore appear to be another instance of local outburst, similar to those brought to light by the survey in Western and Southwestern Colorado.

Extensive areas of the district are occupied by sedimentary or stratified rocks, which were referred to the Lower Silurian, Carboniferous, Jura-Triassic, Cretaceous, and Tertiary ages. These rocks have been

subjected to considerable folding and displacements in the different portions of the district.

One of the most interesting discoveries was that of the presence of fish-remains in the Lower Carboniferous. Several forms were found, identical with or closely allied to Keokuk species of the genera *Cladodus*, *Petalodus*, *Anthiodus*, and *Helodus*.

In the upper basin of Snake River, Tertiary lacustrine beds occur. These are probably the equivalents of the lake-beds of Dr. Hayden.

The Téton Range was examined, and found to be a gigantic monoclinal ridge, with a metamorphic and granitic nucleus, which forms a lofty exceedingly rugged, jagged crest, extending in a north and south direction three-fourths the length of the range, culminating in Mount Hayden.

In Jackson's Basin, east of the Teton Range, a vast accumulation of morainal matter was noted. Along the west side of the basin extensive morainal accumulations occur, which have been cut into beautiful terraces by Snake River.

Calcareous tufa, indicating the presence of springs, was found at the mouth of Salt River, in a small basin east of Lincoln Valley, &c. None of these, however, are comparable with the enormous spring deposits met with at the northeastern foot of the Wind River Mountains, in the upper portion of the Wind River Valley, which were hastily examined late in the season.

The geological notes given above present only the salient features of the season's work.

PALEONTOLOGY.

The necessity of a careful examination of the various geological formations in the field, and a review by a practical paleontologist of the various districts that have from year to year been surveyed by the different geologists of this and other surveys, has been long felt. Such a work, indeed, was imperatively necessary before a consistent and comprehensive classification of the formations could be established. This duty was assigned to Dr. C. A. White, the paleontologist of this survey, and he took the field at the beginning of the past season and continued his labors until its close. The special duty with which he was charged was to pursue such lines of travel as would enable him to make critical examination of the geological formations in succession as they are exposed to view on both sides of the Rocky Mountain chain, and also on both sides of the Uintah chain; to collect and study the fossils of these formations in such detail as to settle, as far as possible, the questions of the natural and proper vertical limits of the formations, their geographical range, their correlation with each other, and to define the paleontological characteristics of each.

He has pursued his researches with such success during the past season as to demonstrate the necessity of continuing this class of investigations by various lines of travel across what is generally known as the

great Rocky Mountain region, especially those portions of it that have been surveyed, as well as those in which surveys are in progress.

Among other important results, he has shown the identity of the lignitic series of strata east of the Rocky Mountains in Colorado with the Fort Union group of the Upper Missouri River, and also its identity with the great Laramie group of the Green River Basin and other portions of the region west of the Rocky Mountains. He also finds the planes of demarkation between any of the Mesozoic and Cenozoic groups, from the Dakota to the Bridger inclusive, to be either very obscure or indefinable; showing that whatever catastrophal or secular changes took place elsewhere during all that time, sedimentation was probably continuous in what is now that part of the continent from the earliest to the latest of the epochs just named. Other results and further details of the season's work will appear in the following paragraphs.

The general course of travel pursued by Dr. White during the season was as follows, not including the numerous detours, meanderings, and side trips which the work necessitated: Outfitting at Cheyenne, he journeyed southward, traversing in various directions a portion of the great plains which lie immediately adjacent to the eastern base of the Rocky Mountains in Colorado. The most easterly point thus reached was some sixty miles east of the base of the mountains and the most southerly point about twenty-five miles south of Denver. Returning to Denver to renew his outfit, he crossed the Rocky Mountains by way of Boulder Pass, through Middle Park. After making certain comparative examinations of the Mesozoic and Cenozoic formations in Middle Park he proceeded westward to the headwaters of the Yampa River, following that stream down to the western foot-hills of the Park Range of mountains.

Here resuming his comparative examinations of the Mesozoic and Cenozoic strata, he passed down the valley of the Yampa as far as Yampa Mountain, one of those peculiar and remarkable up-thrusts of Paleozoic rocks through Mesozoic strata. In all this area, as well as that between the Yampa and White Rivers, the Laramie group reaches a very great and characteristic development, and it received careful investigation, yielding some of the most important results of the season's work. Crossing the ground between the two rivers named to White River Indian agency, thence down White River Valley about one hundred miles; thence to Green River, crossing it at the southern base of the Uintah Mountains, making many detours on the way, he reviewed the geology of the region which he had surveyed during the previous season. This review brought out not only the important paleontological facts before referred to, but it also added materially to the elucidation of the geological structure of the region which lies between the eastern end of the Uintah Mountain Range on the west and the Park Range on the east.

Beyond Green River he pursued his travels westward, studying the Mesozoic and Cenozoic strata that flank the Uintah Range upon its south

side, and making comparisons of both their lithological and paleontological characteristics.

In this way he traversed the whole length of the Uintah Range, crossing at its junction with the Wasatch Range over into the valley of Great Salt Lake. Recrossing the Wasatch to the north side of the Uintah Range, he continued his examinations of the Cretaceous and Tertiary strata into and entirely across the great Green River Basin, leaving the field at the close of the season at Rawlins Station, on the Union Pacific Railroad.

A general statement of the results of the season's work has been given in a previous paragraph, but the following additional summary will make the statement somewhat clearer, being made after the route of the season's travel has been indicated. The formations of later Mesozoic and earlier Cenozoic ages, especially those to which Dr. White, in former publications, has applied the provisional designation of "Post-Cretaceous," have received particular attention. The extensive explorations of Dr. Hayden in former years, and the paleontological investigations of the late Mr. Meek, pointed strongly to the equivalency of the Fort Union beds of the Upper Missouri River with the lignitic formation as it exists along the base of the Rocky Mountains in Colorado, and also to the equivalency of the latter with the Bitter Creek series west of the Rocky Mountains. The investigations of this year have fully confirmed these views by the discovery not merely of one or two doubtful species common to the strata of each of these regions, but by an identical molluscan fauna ranging through the whole series in each of the regions named.

This shows that the strata just referred to all belong to one well-marked period of geological time, to the strata of which has been applied the name of "Laramie group," (Point of Rocks group of Powell). His investigations also show that the strata, which in former reports by himself and Professor Powell have been referred to the base of the Wasatch group, also belong to the Laramie group, and not to the Wasatch. He has reached this later conclusion not merely because there is a similarity of type in the fossils obtained from the various strata of the Laramie group with those that were before in question, but by the specific identity of many fossils that range from the base of the Laramie group up into and through the strata that were formerly referred to the base of the Wasatch. Furthermore, some of these species are found in the Laramie strata on both sides of the Rocky Mountains. Thus the vertical range of some of these species is no less than three thousand feet, and their present known geographical range more than a thousand miles.

Besides the recognition of the unity of the widely-distributed members of the formation of this great geological period, bounded by those of undoubted Cretaceous age below and those of equally undoubted Tertiary age above, his further observations have left comparatively

little doubt that the "Lake Beds" of Dr. Hayden, as seen in Middle Park, the "Brown's Park group" of Professor Powell, and the "Uinta group" of Mr. King, all belong to one and the same epoch, later than and distinctly separate from the Bridger group.

In that portion of the region which lies adjacent to the southern base of the Uinta Mountain Range, and which is traversed by Lake Fork and the Du Chesne River, not only the Uintah group, but both the Green River and Bridger groups also, are well developed, each possessing all its peculiar and usual characteristics as seen at the typical localities in the great Green River Basin, north of the Uintah Mountains. This, added to the known existence of Bridger strata in White River Valley, and the extensive area occupied by the Green River group between White and Grand Rivers, has added very largely to our knowledge of the southward extension of those formations.

In all the comparative examinations of the formations or groups of strata that have just been indicated, he has paid especial attention to their boundaries or planes of demarkation, crossing and recrossing them wherever opportunity offered, noting carefully every change of both lithological and paleontological characters. While he has been able to recognize with satisfactory clearness the three principal groups of Cretaceous strata, namely, the Dakota, Colorado, and Fox Hills, on both sides of the Rocky and Uinta Mountains, respectively, they evidently constitute an unbroken series, so far as their origin by continuous sedimentation is concerned. While each of the groups possesses its own peculiar paleontological characteristics, it is also true that certain species pass beyond the recognized boundaries of each within the series.

The stratigraphical plane of demarkation between the Fox Hills, the uppermost of the undoubted Cretaceous groups, and the Laramie group, the so-called Post-Cretaceous, is equally obscure; but the two groups are paleontologically very distinct, inasmuch as the former is of marine origin, while the latter, so far as is now known, contains only brackish-water and fresh-water invertebrate forms. He reports a similar obscurity, or absence of a stratigraphical plane of demarkation, between the Laramie and Wasatch groups, although it is there that the final change from brackish to entirely fresh water took place over that great region. Furthermore, he finds that while the three principal groups of the fresh-water Tertiary series west of the Rocky Mountains, namely, the Wasatch, Green River, and Bridger groups, have each peculiar characteristics, and are recognizable with satisfactory distinctness as general divisions, they really constitute a continuous series of strata, not separated by sharply-defined planes of demarkation, either stratigraphical or paleontological.

During the progress of the field-work, as above indicated, large and very valuable collections of fossils have been made, all of which will constitute standards of reference in the future progress of the work, and quite a large number of the species are new to science. These are

now being investigated, and will be published in the usual paleontological reports of the survey.

FOSSIL ENTOMOLOGY.

Messrs. S. H. Scudder, of Cambridge, and F. C. Bowditch, of Boston, spent two months in Colorado, Wyoming, and Utah, in explorations for fossil insects, and in collecting recent Coleoptera and Orthoptera, especially in the higher regions. They made large collections of recent insects at different points along the railways from Pueblo to Cheyenne and from Cheyenne to Salt Lake, as well as at Lakin, Kans., Garland and Georgetown, Colo., and in various parts of the South Park and surrounding region.

For want of time they were obliged to forego an anticipated trip to White River, to explore the beds of fossil insects known to exist there. Ten days were spent at Green River and vicinity in examining the Tertiary strata for fossil insects, with but poor results; the Tertiary beds of the South Park yielded but a single determinable insect, but near Florissant the Tertiary basin, described by Mr. Peale in one of the annual reports of the Survey, was found to be exceedingly rich in insects and plants.

In company with Rev. Mr. Lakes, of Golden, Mr. Scudder spent several days in a careful survey of this basin and estimates the insect-bearing shales to have an extent at least fifty times as great as those of the famous locality at Œningen in Southern Bavaria. From six to seven thousand insects and two or three thousand plants have already been received from Florissant, and as many more will be received before the close of the year.

Mr. Scudder was also able to make arrangements in person with parties who have found a new and very interesting locality of Tertiary strata in Wyoming, to send him all the specimens they work out, and he confidently anticipates receiving several thousand insects from them in the course of the coming winter. The specimens from this locality are remarkable for their beauty. There is, therefore, every reason to believe the Tertiary strata of the Rocky Mountain region are richer in remains of fossil insects than any other country in the world, and that within a few months the material at hand for the elaboration of the work on fossil insects, which Mr. Scudder has in preparation for the survey, will be much larger than was ever before subject to the investigation of a single naturalist.

ZOOLOGY.

Prof. Joseph Leidy, the eminent comparative anatomist and microscopist, made his second visit to the West the past season, under the auspices of the survey. He made a careful exploration of the country about Fort Bridger, Uintah Mountains, and the Salt Lake Basin, in search of rhizopods. He has been engaged for a long time on a memoir

on this subject, which will eventually form one of the series of the quarto Reports of the Survey.

The rhizopods are the lowest and simplest forms of animals, mostly minute, and requiring high power of the microscope to distinguish their structure. While most of them construct shells of great beauty and variety, their soft part consists of a jelly-like substance. This the animal has the power of extending in threads or finger-like processes, which are used as organs of commotion and prehension, often branching. From the appearance of their temporary organs, resembling roots, the class of animals has received its name of rhizopoda, meaning literally root-footed.

In compensation for the smallness of these creatures, they make up in numbers, and it is questionable whether any other class of animals exceed them in importance in the economy of nature. Geological evidence shows that they were the starting-point of animal life in time, and their agency in rock-making has not been exceeded by later higher and more visible forms.

With the marine kind, known as foraminifera, we have been longest familiar. The beautiful many-chambered shells of these—for the most part just visible to the naked eye—form a large portion of the ocean-mud and the sands of the ocean-shore. Shells of foraminifera likewise form the basis of miles of strata of limestone, such as the chalk of England and the limestones of which Paris and the pyramids of Egypt are built.

Fresh-water rhizopods, though not so abundant as marine forms, are nevertheless very numerous. They mainly inhabit our lakes, ponds, and standing waters, but they also swarm in sphagnous swamps, and ever live in newest earth. Professor Leidy has devoted several years of study to the fresh-water rhizopods of the eastern portion of our country, and his especial object in the past expedition was to investigate those which are to be found in the elevated regions of the Rocky Mountains.

BOTANY.

The botany of the Survey was represented the past season by the two great masters of that department, Sir Joseph D. Hooker, director of the Gardens of Kew, England, and president of the Royal Society of London; and Prof. Asa Gray, of Cambridge, Mass. Their examinations extended over a great portion of Colorado, Wyoming, Utah, Nevada, and California. Their investigation into the alpine floras and tree vegetation of the Rocky Mountains and Sierra Nevada enabled them to give a clear idea of the relations and influence of the climatic conditions on both sides of the great mountain-ranges.

Sir Joseph Hooker, whose botanical researches embrace the greater part of Europe; the Indies, from the bay of Bengal across the Himalayas to Thibet; the Antarctic regions and the southern part of South America, New Zealand, Australia, South Africa, Morocco, and Asia

Minor, presents in the English periodical "Nature" for October 25 an outline of his studies during the season, and this outline when filled out will form a most important report for the Eleventh Annual Report of the Survey. It will be seen at a glance that the report will be of the most comprehensive character, and cannot fail to be of the highest interest to our people. The tree vegetation, and especially the coniferæ, were made special objects of study, and many obscure points were cleared up.

Of a section of the Rocky Mountains comprising Colorado, Wyoming, and Utah, Dr. Hooker says:

Such a section of the Rocky Mountains must hence contain representatives of three very distinct American floras, each characteristic of immense areas of the continent. There are two temperate and two cold or mountain floras, viz: (1) a prairie flora derived from the eastward; (2) a so-called desert and saline flora derived from the west; (3) a subalpine; and (4) an alpine flora; the two latter of widely different origin, and in one sense proper to the Rocky Mountain Ranges.

The principal American regions with which the comparison will have first to be instituted are four. Two of these are in a broad sense humid; one, that of the Atlantic coast, and which extends thence west to the Mississippi River, including the forested shores of that river's western affluents; the other, that of the Pacific side, from the Sierra Nevada to the western ocean; and two inland, that of the northern part of the continent extending to the Polar regions, and that of the southern part extending through New Mexico to the Cordillera of Mexico proper.

The first and second (Atlantic plus Mississippi and the Pacific) regions are traversed by meridional chains of mountains approximately parallel to the Rocky Mountains, namely, on the Atlantic side by the various systems often included under the general term Appalachian, which extend from Maine to Georgia, and on the Pacific side by the Sierra Nevada, which bound California on the east. The third and fourth of the regions present a continuation of the Rocky Mountains of Colorado and Utah, flanked for a certain distance by an eastern prairie flora extending from the British Possessions to Texas, and a western desert or saline flora, extending from the Snake River to Arizona and Mexico. Thus the Colorado and Utah floras might be expected to contain representatives of all the various vegetations of North America, except the small tropical region of Florida, which is confined to the extreme southeast of the continent.

The most singular botanical feature of North America is unquestionably the marked contrast between its two humid floras, namely, those of the Atlantic plus Mississippi, and the Pacific one; this has been ably illustrated and discussed by Dr. Gray in various communications to the American Academy of Sciences, and elsewhere, and he has further largely traced the peculiarities of each to their source, thus laying the foundations for all future researches into the botanical geography of North America; but the relations of the dry intermediate region either to these or to the floras of other countries had not been similarly treated, and this we hope that we have now materials for discussing.

Dr. Hooker sums up the results of the joint investigations of Dr. Gray and himself, aided by Dr. Gray's previous intimate knowledge of the American flora, from the Mississippi to the Pacific coast:

That the vegetation of the middle latitudes of the continent resolves itself into three principal meridional floras, incomparably more diverse than those presented by any similar meridians in the Old World, being, in fact, as far as the trees, shrubs, and many genera of herbaceous plants are concerned, absolutely distinct. These are the two humid and the dry intermediate regions above indicated.

Each of these, again, is subdivisible into three, as follows:

1. The Atlantic slope plus Mississippi region, subdivisible into (a) an Atlantic, (β) a Mississippi Valley, and (γ) an interposed mountain region with a temperate and subalpine flora.

2. The Pacific slope, subdivisible into (a) a very humid, cool, forest-clad coast range; (β) the great, hot, drier Californian valley, formed by the San Juan River flowing to the north, and the Sacramento River flowing to the south, both into the Bay of San Francisco; and (γ) the Sierra Nevada flora, temperate, subalpine, and alpine.

3. The Rocky Mountain region (in its widest sense extending from the Mississippi beyond its forest region to the Sierra Nevada), subdivisible into (a) a prairie flora, (β) a desert or saline flora, (γ) a Rocky Mountain proper flora, temperate, subalpine, and alpine.

As above stated, the difference between the floras of the first and second of these regions is specifically, and to a great extent generically, absolute; not a pine or oak, maple, elm, plane, or birch of Eastern America extends to Western, and genera of thirty to fifty species are confined to each. The Rocky Mountain region again, though abundantly distinct from both, has a few elements of the eastern region and still more of the western.

Many interesting facts connected with the origin and distribution of American plants, and the introduction of various types into the three regions, presented themselves to our observation or our minds during our wanderings. Many of these are suggestive of comparative study with the admirable results of Heer's and Lesquereux's investigations into the Pliocene and Miocene plants of the north temperate and frigid zones, and which had already engaged Dr. Gray's attention, as may be found in his various publications. No less interesting are the traces of the influence of a glacial and a warmer period in directing the course of migration of Arctic forms southward, and Mexican forms northward in the continent, and of the effects of the great body of water that occupied the whole saline region during (as it would appear) a glacial period.

Lastly, curious information was obtained respecting the ages of not only the big trees of California, but of equally aged pines and junipers, which are proofs of that duration of existing conditions of climate for which evidence has hitherto been sought rather among fossil than among living organisms.

ARCHÆOLOGY.

Up to the year 1874 rumor had been telling many marvelous stories of strange and interesting habitations of a forgotten people, who once occupied the country about the headwaters of the Rio San Juan, but these narrations were so interwoven with romance that but few people placed much reliance upon them. To those well versed in archæology, ruins of an extensive and interesting character were known to exist throughout New Mexico and Arizona, and the various reports of Abert, Johnson, Sitgreaves, Simpson, Whipple, Newberry, and others form our most interesting chapter in ancient American history; but their researches, aside from the meager accounts published by Newberry, throw no light on the marvelous cliff dwellings and towns north of the San Juan. In 1874 the photographic division of the United States Geological Survey was instructed, in connection with its regular work, to visit and report upon these ruins, and in pursuance of this object made a hasty tour of the region about the Mesa Verde and the Sierra el Late, in Southwestern Colorado, the results of which trip, as expressed by Bancroft, in the Native Races of the Pacific Coast, "although made known to the world only through a three or four days' exploration by a party of three men, are of the greatest importance." A report was made and published, with fourteen illustrations, in the Bulletin of the United

States Geological and Geographical Survey of the Territories, second series, No. 1.

The following year the same region was visited by Mr. W. H. Holmes, one of the geologists of the Survey, and a careful investigation made of all the ruins. Mr. Jackson, who had made the report the previous year, also revisited this locality, but extended his explorations down the San Juan to the mouth of the De Chelly, and thence to the Moqui villages in Northeastern Arizona. Returning, the country between the Sierra Abajo and La Sal and the La Plata was traversed, and an immense number of very interesting ruins were first brought to the attention of the outside world by the report which was published the following winter in the Bulletin of the Survey, Vol. II, No. 1.

The full report on these ancient ruins, so far as the Survey is concerned, was published in the Tenth Annual Report of the Survey, with many illustrations.

The occasion of the Centennial Exhibition at Philadelphia led to the idea of preparing models of these ruins for the clearer illustration of their peculiarities, four of which were completed in season for the opening of the exhibition. Since that time not only the number of these interesting models has been increased, but they have been perfected in execution and faithful delineation of these mysterious remains of an extinct race who once lived within the borders of our western domain.

A study of these models will give a very excellent idea of the ruined dwellings themselves. The first of these models, executed by Mr. Holmes, represents the cliff house of the Mancos Cañon, the exterior dimensions of which are 28 inches in breadth by 46 inches in height, and on a scale of 1.24, or two feet to the inch. This is a two-story building, constructed of stone, occupying a narrow ledge in the vertical face of the bluff 700 feet above the valley, and 200 feet from the top. It is 24 feet in length and 14 feet in depth, and divided into four rooms on the ground-floor. The beams supporting the second floor are all destroyed. The doorways, serving also as windows, were quite small, only one small aperture in the outer wall facing the valley. The exposed walls were lightly plastered over with clay, and so closely resembled the general surface of the bluff that it becomes exceedingly difficult to distinguish them at a little distance from their surroundings.

The second model of this series was constructed by Mr. Jackson, and represents the large "cave town," in the valley of the Rio de Chelly near its junction with the San Juan. This town is located upon a narrow bench, occurring about 80 feet above the base of a perpendicular bluff some 300 feet in height. It is 545 feet in length, about 40 feet at its greatest depth, and shows about 75 apartments on its ground-plan. The left-hand third of the town, as we face it, is overhung some distance by the bluff, protecting the buildings beneath much more perfectly than the others. This is the portion represented by the model. A three-story tower forms the central feature; upon either side are rows of

lesser buildings, built one above another upon the sloping floor of rock. Nearly all these buildings are in a fair state of preservation. This model is 37 by 47 inches, outside measurements, and the scale 1.72, or 6 feet to the inch. A "restoration" of the above forms the third in the series, of the same size and scale, and is intended, as its name implies, to represent as nearly as possible the original condition of the ruin. In this we see that the approaches were made by ladders and steps hewn in the rock, and that the roofs of one tier of rooms served as a terrace for those back of them, showing a similarity, at least, in their construction to the works of the Pueblos in New Mexico and Arizona. Scattered about over the buildings are miniature representations of the people at their various occupations, with pottery and other domestic utensils.

The "triple-walled tower," at the head of the McElmo, is the subject of the fourth model, and represents, as indicated by its title, a triple-walled tower, situated in the midst of a considerable extent of lesser ruins, probably of dwellings, occupying a low bench bordering the dry wash of the McElmo. The tower is 42 feet in diameter, the wall 2 feet thick, and now standing some 12 feet high. The two outer walls inclose a space of about 6 feet in width, which is divided into 14 equally-sized rooms, communicating with one another by small window-like doorways. The next is a "cliff-house" in the valley of the Rio de Chelly. It is about 20 miles above the cave town already spoken of. This is a two-story house, about twenty feet square, occupying a ledge some 75 feet above the valley, and overhung by the bluff. The approach from the valley is by a series of steps hewn in the steep face of the rock; and this method was the one most used by the occupants, although there is a way out to the top of the bluff. This model is 42 inches in height by 24 broad, and is built upon a scale of 1.36.

Téwa, one of the seven Moqui towns in Northeastern Arizona, is a very interesting and instructive model, representing, as it does, one of the most ancient and best authenticated of the dwellings of a people who are supposed to be the descendants of the cliff-dwellers. Téwa is the first of the seven villages forming the province as we approach them from the east, and occupies the summit of a narrow mesa some 600 feet in height and 1,200 yards in length, upon which are also two other somewhat similar villages. The approach is by a circuitous roadway hewn in the perpendicular face of the bluff, which surrounds the mesa upon all sides. It is the only approach accessible for animals to the three villages. Other ladder-like stairways are cut in the rock, which are used principally by the water carriers, for all their springs and reservoirs are at the bottom of the mesa. This village is represented upon a scale of 1 inch to 8 feet, or 1.96. The dimensions of the model are 36 inches in length, 29 inches in width, and 14 inches in height.

In the spring of 1877, Mr. Jackson made a tour over much of the northern part of New Mexico, and westward to the Moqui towns in

Arizona, and secured materials for a number of very interesting models, illustrating the methods of the Pueblos or town-builders in the construction of their dwellings. Two villages have been selected for immediate construction, as showing the most ancient and best known examples of their peculiar architecture, viz: Taos and Acoma; the one of many-storied, terraced houses, and the other built high up on an impregnable rock. The model of Taos is now completed, the dimensions of which are 42 by 39 inches, and the scale one inch to twenty feet, 1:240.

Of this town Davis says:

> It is the best sample of the ancient mode of building. Here are two large houses three or four hundred feet in length, and about one hundred and fifty feet wide at the base. They are situated upon opposite sides of a small creek, and in ancient times are said to have been connected with a bridge. They are five and six stories high, each story receding from the one below it, and thus forming a structure terraced from top to bottom. Each story is divided into numerous little compartments, the outer tier of rooms being lighted by small windows in the sides, while those in the interior of the building are dark, and are principally used as storerooms. * * * The only means of entrance is through a trap-door in the roof, and you ascend from story to story by means of ladders on the outside, which are drawn up at night.

Their contact with Europeans has modified somewhat their ancient style of buildings, principally in substituting doorways in the walls of their houses for those in the roof. Their modern buildings are rarely over two stories in height, and are not distinguishable from those of their Mexican neighbors. The village is surrounded by an adobe wall, which is first included within the limits of the model, and incloses an area of eleven or twelve acres in extent. Within this limit are four of their *estufas*, or secret council-houses. These are circular underground apartments, with a narrow opening in the roof, surrounded by a palisade, ladders being used to go in and out.

These models are first carefully built up in clay, in which material all the detail is readily secured, and are then cast in plaster, a mold being secured by which they are readily multiplied to any extent. They are then put in the hands of the artists and carefully colored in solid oil paints to accurately resemble their appearance in nature, and, in the case of restorations or modern buildings, all the little additions are made which will give them the appearance of occupation. The survey is in possession of the data for the construction of many more models, and they will be brought out as opportunity is given. They have also, in connection with the views, multiplied many of the curious pieces of pottery which have been brought back from that region by the various parties connected with the survey.

These models are now in the possession of several of the leading museums of this country and of Europe, in Washington, Princeton, Cambridge, New York, London, Paris, and Berlin, and will serve more fully to illustrate and perpetuate our knowledge of this singular period in our country's history.

THE VALUE OF PALEONTOLOGY IN THE WORK OF THE SURVEY.

By examining the publications of the survey, it will be seen that much attention has been given to the ancient fauna and flora of our Western Territories. The memoirs by Leidy, Cope, Lesquereux, Scudder, Meek, and White will always remain as imperishable monuments of their labors in their respective departments. The value of their studies in connection with geological explorations and surveys is often in danger of being underestimated by not being correctly understood; but the importance of such work may be indicated by the fact that it is upon the study of fossil remains that the whole system of geology was originally based, and which study now forms the only reliable foundation for the correct classification of the stratified rocks of the earth.

The study of the fossil remains of animals and plants not only adds immensely to the sciences of zoology and botany, giving them a completeness which could never be attained by the study of living forms alone, but it has immediate and direct practical application in the elucidation of the systematic geology of every region as well as a general and universal classification of the stratified rocks. It is unfortunately the case that many attempts have been made by persons reporting upon the geology of certain districts to base the classification of the formations within it upon the lithological characteristics alone, ignoring the fossil remains as not being of practical value for such purposes. While this method of classification is often approximately correct for limited areas, it is even in such cases often erroneous and always subject to serious error, and in larger regions wholly unreliable. The history of geology contains cases in which resurveys of considerable districts, at great expense, have been rendered necessary by a failure to follow the indications afforded by the fossil remains of the strata concerned.

The following brief statement may be taken as illustrating the method of applying a knowledge of fossil remains to the classification of the strata containing them. The different groups of strata, or the formations that make up the great series of stratified rocks of the earth, from the earliest to the latest formed, are each, respectively, characterized by their own peculiar kinds or types of fossils. The paleontologist studies these, and, by familiar acquaintance with their respective characteristics, he is able to recognize the particular formations to which they belong wherever he may discover them, whether then associated with other formations or not. Each formation being thus characterized, he finds that they hold definite and invariable relations of superposition to each other; and that this order of their relation is never interchanged or reversed; for an animal or vegetable type once introduced and become extinct has never been repeated, but it has left the evidence of its former existence to mark an epoch in the passage of geological time. By this means the paleontologist is able to determine the position in the great scale of formations, any one of these that he may discover in any part

of the earth, even if the others are not there present for study in direct connection. In no other way can the relative geological age of formations be accurately known. Therefore, admitting the utility of geology at all, the practical utility of paleontology must be plainly recognized.

But it is not only in this general way that the practical utility of paleontology is shown, for there are many ways in which its application gains or saves from useless expenditure great sums of money.

The study of fossil remains found in the strata which are associated with beds of coal, and those found in the formations which respectively underlie and overlie the coal formation, show that each is so characterized by its own peculiar fossils that they can be unhesitatingly recognized by them, even when no coal is visible, and the lithological character of the strata is found to be different from what it was where last observed. Thus, if, in the geological examination of a district, the rocks at any certain place are found to contain the fossils peculiar to the formation which belongs above that which contains the coal, the latter lies beneath, and coal may reasonably be sought by deep mining. If, on the contrary, the formation examined be found to contain the fossils peculiar to the one whose place in the geological scale is beneath the coal formation, search for coal in the whole region in which that formation is at the surface is sure to result in failure, because the coal formation has either been removed by erosion, or it was never deposited there. In either case it is a certain waste of money to search for coal under such circumstances.

The history of mining has been said to be a history of failures; and this is doubtless true as regards preliminary operations or prospecting. It is especially true as regards prospecting for coal, and it is safe to say that far the larger part these failures might have been avoided by a moderate amount of paleontological knowledge and an observance of its teachings.

The sums which have been expended by private enterprise in the search for coal in the different States of the Union, in places where one possessing the merest rudiments of paleontological knowledge would have known better, is enormous; and this waste of labor and capital can be stopped only by a proper diffusion of the knowledge referred to.

Besides the determination of these facts of immediate practical use in limited districts, the paleontological study of the formations enables us to map large regions and to indicate the boundaries within which it is reasonable to search for coal or other valuable products, and beyond which such search is sure to result in failure. Many examples of this kind might be cited, but these remarks will be closed with a single illustration drawn from the recorded results of this survey. Coal is found abundantly in the Laramie formation at the eastern base of the Rocky Mountains in Colorado. The associated strata are found to be characterized by peculiar fossils. The different formations which immediately underlie the surface of the great plains east of those mountains are so

leveled off and obscured by soil *débris* that they can nowhere be recognized or distinguished from each other except by their fossils. Chance exposures at long intervals, and the sinking of occasional wells, have revealed the peculiar fossils of that coal-bearing formation at points as far out on the plains as Western Kansas, and it is reasonable to infer that the formation has a still wider range than is thus indicated by such facts at present known. It is therefore reasonable to expect to find coal over a large region far out on those plains which is wholly destitute of all other kinds of fuel. Important districts within that region will thus be rendered profitably habitable, which would otherwise be worthless.

The Survey is under great obligations to Dr. Elliott Coues for his continuous and able superintendence of the publications of the past year. He was so fully occupied that he could not perform any extended zoological work in the field. A synopsis of the numerous publications of the Survey will be prepared by him for the Annual Report for 1878.

The thanks of the Survey are also due to Mr. James Stevenson, executive officer, for his able management both in the field and in the office.

Very respectfully, your obedient servant,

F. V. HAYDEN,
United States Geologist.

To the SECRETARY OF THE INTERIOR.

PART I.

GEOLOGY AND PALÆONTOLOGY.

REPORT OF F. M. ENDLICH, S. N. D.

LETTER OF TRANSMITTAL.

WASHINGTON, D. C., *May* 15, 1878.

SIR: I have the honor herewith to submit my report of 1877 as geologist of the Sweetwater division. The party to which this area was assigned for exploration consisted of G. B. Chittenden, topographer directing; Charles H. Howes, assistant topographer; Edward T. Clymer, assistant geologist, and myself. Two packers and a cook completed the personnelle. According to instructions received, we started from Cheyenne on May 31, by rail, for Salt Wells station. On June 2 we commenced our field-work. Making Camp Stambaugh and Rawlin's Springs our bases of supplies, we arranged our trips so as to reach them at the proper time. To the officers of both Camp Stambaugh and Camp Brown we are under great obligations for the efficient aid they kindly rendered us in many instances. Our work was facilitated and we were enabled to avoid many annoyances through their cheerfully extended courtesy.

During the season two of the members of our party were taken sick with mountain fever, but both recovered fully. After having completed my portion of the work, I left the party on September 17, rode to Rawlings' and proceeded from there to the region of Evanston, Wyo., in order to examine the coal-mines. September 23, the rest of the party reached Fort Steele and disbanded. So as to comply with the orders which required our return by October 1, a small portion of the district assigned to us remained unsurveyed. During the season we rode over 2,500 miles. The pack-train, in the same time marched 1,500 miles.

Owing to the protracted, severe illness of Mr. Chittenden, no map has been prepared as yet showing the results of our labors. As no good map of that region exists, furnishing a sufficiently large scale, I am forced to modify the usual arrangement of my report. No references can be made to localities which are not represented by the older maps, and descriptions thereof must necessarily suffer. In order to remedy, as far as possible, this want, I have prefaced my report with an itinerary. In this will be found a connected account of the trip, which may aid in making more intelligible the allusions in subjoined pages to the names of places and regions we visited. The report proper is divided into five chapters. Of these, the first treats of the physical and, in part, faunal character of the country surveyed; the second describes the surface and structural geology of the Wind River Range and the country east of it; the third treats of the country comprised within the Sweetwater drainage; the fourth discusses the low southern country; and the fifth contains a review of the economic geology of the district, besides a "Conclusion." An appendix has been added, containing a catalogue of the minerals found within our district. The study of the coal-mines will be the subject of a separate report.

Owing to the want of a reliable map, much information has necessarily been omitted which otherwise might have been embodied in this report. The distances given, from point to point, are not measured or calculated,

but estimated. For this reason I would beg leave to submit the strictly geological report merely as a preliminary one, expecting to enlarge it and furnish a larger number of definitely established data at some future time, after the necessary maps have been prepared.

To the members of the party, and especially to my assistant, Mr. Clymer, are due my sincere thanks for their coöperation during the field-season. Dr. Coues has kindly furnished me with the names of various animals which we observed during the trip, and I am under obligations to him therefor. Dr. Vasey has rendered the same service with reference to the plants.

Hoping that the subjoined report may meet your requirements, I have the honor to remain, sir, very respectfully, your obedient servant.

FREDERIC M. ENDLICH.

Dr. F. V. HAYDEN,

Geologist-in-charge United States Geological and Geographical Survey of the Territories.

REPORT ON THE GEOLOGY OF THE SWEETWATER DISTRICT.

By F. M. Endlich, S. N. D.

ITINERARY.

During the summer season of 1877, a district was assigned to us lying between north latitude 41° 45′ and 43°, and west longitude 107° and 109° 30′, within the Territory of Wyoming. A portion of the ground had been covered by Frémont's expedition in 1842–'43, and by Dr. Hayden's explorations during 1870. For the purpose of continuing the regularly mapped survey of the Territories, it was necessary that connected explorations of this region should be made. The area assigned to us covered 11,300 square miles, but a portion thereof remained unsurveyed, owing to the advanced season. Much that heretofore was unknown within the district has been discovered, and points remaining in doubt have been cleared up. As no map can accompany the subjoined geological report, this itinerary may facilitate the determination and recognition of localities referred to therein. A certain amount of repetition will occur; but as the one description is prepared from the standpoint of a traveller, and the other from that of a geologist, it may be hoped that each will present features which the other does not contain.

FROM SALT WELLS TO CAMP STAMBAUGH.

Having left Cheyenne by rail May 31, we reached Salt Wells Station early on June 1. The day was fully occupied in arranging and classifying the provisions, instruments, ammunition, and personal property of the party. As might be expected, the mules, which had for seven months been perfectly idle, exhibited a degree of friskiness that promised characteristic developments upon their first packing. Proceeding in a direction a little west of north, we left the Union Pacific Railroad and reached our first camp on Packer's Creek. It was found to be dry, but water was obtained from some small alkaline pools in the vicinity. Early on the day following we started, after having collected our straying animals, and travelled in a direction north of east. In the distance some prominent black hills appeared, indicating to us the probability of finding water, and furnishing good points for the purposes of topographical work. During the entire day we saw no water, excepting that which we received most plentifully in the shape of a drenching rain. A stiff wind blowing it directly into our faces, rather disconcerted the mules, and it required constant "argument" to keep them in line. Some very characteristic scenery was found on the way, indicating that we had left the Cretaceous area and entered that of the Tertiary formation. Fluviatile erosion has carved deep, narrow cañons into the readily yielding sandstones and marls. Depositing the detritus in conveniently located valleys, these have been filled with loose soil, often to the depth of 30 feet and more. The first thing that attracted our attention was

the absence of Indian trails. This indicated a scarcity of water, grass, and game. Subsequently we found these indications amply borne out by facts. Having ascended a high ridge, we saw before us a series of gullies and small cañons that presented very typically the aspect of the Wasatch group. Vertical or very steep walls of sandstone and marl were carved by erosion. Bright colors, white, yellow, orange, red, and maroon, blending in beautiful harmony, tended to complete the picture. Scattering pines and cedars relieved the uniformity of rock-exposures. By four o'clock we had not found any water, although we were within the limits of a small group of basaltic hills. Between our position at that time and the highest hill of that region stretched a band of loose sand about 4 miles wide. Riding over this mass, which has been accumulated here and elsewhere by the prevailing westerly winds, our mules sank in knee-deep. Tired as they were by their march, carrying heavy loads for the first time after months of inactivity, they became very much fatigued. About sundown we reached the base of the hill for which we had been heading all day, and, after wading through a swamp, treacherous and filled with quicksands, we struck camp near a small spring. Close by was a lake of considerable size, the white shores of which indicated the nature of its water. Timber was a scarce article, and sage-brush furnished the fire for cooking and for warming ourselves after a chilly, wet day. The hill or mountain at the base of which we were encamped we named *Essex Mountain*. For two days our camp remained stationary, while stations were made on the hills within a radius of 15 miles. We then found that reaching this point had been very fortunate, as no water was to be seen for many miles.

On *June* 6, we rode from Mount Essex in a westerly direction. For the first time a few antelope appeared, but they were very shy, and some bullets sent into their vicinity at 600-yard ranges only added to their fear, without furnishing us with any fresh meat. Toward evening we encamped on a creek, which we named subsequently *White Horse Creek*. During the day we had followed a dim wagon-road, which, so far as we could determine, is what some maps designate as "Evans' route," or the "Old Overland Stage Route." Before long, however, we were obliged to leave it and keep to the left. Alkali water was found in the creek, which at first the animals refused to drink. Sage-brush here grows to such a size that the appellation of "sage-trees" would be justifiable, and it furnished the material for fire. Leaving this camp we continued our journey westward, intending to reach the nearer drainage of Big Sandy Creek. During the day, while riding in the creek valley, we discovered a white horse, which was captured after a short run. It was not one of the noble animals which roam in herds over the "boundless prairie," but was blind, had a stringhalt, and still carried two shoes. We noticed that a portion of its back was covered with wool-like hair, about one and a half inches thick. At the time, this was shedding. About noon we crossed an old emigrant-road, where the deeply-cut furrows told a tale of the hundreds and thousands who had passed over it, some going to their fortunes, others miserably to perish. About three o'clock the sight of telegraph poles showed us that we had reached the stage and mail road between Bryan Station and Camp Stambaugh. We followed it over a rolling country, until, at sundown, we arrived at Dry Sandy Station. This name is aptly chosen. A wide creek-bed is filled to the depth of several feet with fine, light-yellow sand, perfectly dry, except during the seasons of highest water. For a long distance this bright line could be traced, meandering its course through the surrounding sage-brush, until it was lost as a mere silvery line in the distance. At midnight, after having camped, I took the stage

to South Pass City, from there to go to Camp Stambaugh, where I expected to rejoin the party. A disagreeable ride in a snow-storm brought me to South Pass about five o'clock in the morning. Driving on through absolute darkness, it seemed almost like a miracle that the horses kept the road and safely crossed a number of very primitive bridges.

South Pass City is located on Willow Creek, a swiftly-flowing tributary of Sweetwater River. Near Pacific Springs, a favorite camping-place for emigrants, the Tertiary beds suddenly cease, and we enter a metamorphic region. Ten and twelve years ago, ore-bearing lodes were discovered in these metamorphics, gold was washed out of the gulches, and the "Sweetwater Mines" were far-famed for their richness and reported production. Misrepresentation, bad management, and unscrupulous speculation ruined what might have become a flourishing mining district. To-day the town presents a dreary appearance. Many, if not the majority, of its houses are deserted, and broken window-panes, swinging doors, and torn roofs tell a pitiful tale of desolation. On the surrounding hills buildings are located which are in connection with the mines. Very few of the latter are being worked, while a large number appear to be abandoned temporarily. Ascending a steep hill, we passed through a very pretty country, and after a short drive reached Atlantic City. This, too, is located in a narrow valley, and was formerly the active centre of mining operations.

By this time we had approached the Wind River Mountains within but a short distance of their southern base. Viewed from farther south, the highest peaks of the range rose in abrupt forms from the surrounding country. Snow-capped, as yet, they towered far above the foot-hills of the range. Now, the latter prominently occupied the foreground; the former were no longer visible. The character of the country changes entirely with the change of geological formation. Instead of the ever-repeated flat-topped bluff, we here find massive, rolling hills, separated by steeply-inclining valleys with narrow bottoms. Small creeks are found within these, many of which, however, cannot sustain a sufficient amount of water during the dry season to permit them to flow. Quaking asps, some cottonwood, and scattering pines, afford good shelter and wood for camping purposes. A short ride from Atlantic City in a northerly direction brings us to Camp Stambaugh. At the time of my first visit, this post contained a company of the Second Cavalry. The officers received me with the utmost courtesy, and upon the subsequent arrival of the party afforded us very material aid.

Camp Stambaugh, commanded at that time by Captain Spaulding, is situated in a wide valley, surrounded on every side by hills composed of metamorphic schists. Their dark color and very sparse vegetation gives a sombre aspect to the entire scenery. Several small creeks flow within short distances of the post, and I visited them in company with the officers. At a number of places gulch-mining is carried on there, but the miners complain that the gold is so "fine" that it is a very difficult matter to save it. A very decided character, a thorough type of the adventurous western prospector and pioneer, was employed at the post at that time. He was engaged in burning charcoal. From morning until night this old, grey-bearded man, who had seen the snows of more than seventy-five winters, attended to the smoking pile. His sole ambition, his incentive to work, was the prospect of "making a stake" and going to the Bighorn country, there once more to try and gain the gold that rumor located within that famous region. The proceeds of his work he subsequently converted into a donkey, some bacon, flour, a pick, a shovel, and a rifle, and then set out on foot on a journey that

might prove to be a severe one for many a younger man. By the time the gulch-miners had their works in proper order the water supply gave out at many places, and they were forced to abandon the placiers. Much work has been done on the various creeks, and at some points the gravel is carted considerable distances to reach water. The limited supply, however, of this commodity, cuts short the season for active operations, and forbids the erection of such contrivances as might prove to be more remunerative.

Camp Stambaugh was named after Lieut. Charles B. Stambaugh, of the Second Cavalry, who was killed in action with Indians near Miner's Delight on March 4, 1870. It was established as a substation to Fort Bridger, on June 20, 1870, and announced as an independent post August 20, 1870. Its purpose is to afford protection to the settlers of the mining regions. Since that time the Indians have been crowded farther into the mountains, and Camp Brown, 50 miles north, acts as a protector against hostile invasions. The altitude of Stambaugh is about 8,300 feet above sea-level, an elevation that not unfrequently results in injury of health to those stationed there.

June 13, the party reached the post, having travelled from the Dry Sandy to Little Sandy, thence to the mouth of the former creek. From there they crossed over to Pacific Creek, which was followed upward until beyond South Pass City. Leaving camp early on the 13th, one of the party killed the first deer of the season. Stambaugh was reached during the forenoon. By permission of the commanding officer, we were enabled to make camp within the military reservation, near the post Mail and other acceptable representatives of civilization were obtained, and during the day preparations were made to leave the post on the 14th. Obtaining all the information we could about routes and water, the course of the next trip was decided upon, and upon leaving, we promised our hospitable friends to spend that national holiday, the Fourth of July, with them.

FROM STAMBAUGH TO THE UNION PACIFIC RAILROAD.

June 14, we left the post, and after making several stations, reached our camp on the Sweetwater River. During the day a very heavy gale of wind had been blowing, which in the evening turned into a storm. On the first station made, it was impossible to place the instrument on the summit of the hill, because neither tripod nor man could stand there. The westerly winds are severe and very constant throughout the region we had traversed thus far. It seems that the cold air from the mountains rushes downward with great velocity, and finding nothing to impede its progress, sweeps across the flat country with surprising violence. More than once the wind interfered with our work, rendering the occupation of points almost an impossibility. As the daily temperature decreased in the evening, the wind gradually died out, and did not rise again until nine or ten o'clock in the morning. Enormous accumulations of sand, drifting into dunes, show that for centuries, if not ages, the same conditions have existed in this section of country. A belt of "sand-hills," about 10 miles wide and 75 miles in length, trends from south of west to north of east across our district, proving by its presence the long-continued process that located it there.

Sweetwater Valley, in which we were camped, is at that point narrow, confined between steep hills of metamorphic schists. Willow brush and some aspen are found near the stream. Crossing over to the south side we found ourselves in a series of meadow-like depressions, literally

swarming with antelope. At that season of the year the young ones were still quite small, and great solicitude was manifested on the part of their mothers. Clymer captured one of the little animals alive, after a chase of about two miles. The piteous bleating soon reached the ears of an anxious mother, and she came within twenty yards of us, the very picture of distress. After having tied a string to the little fellow we set him free again.

Our destination was a high, prominent point, where we proposed making a station, and at the base of which we hoped to find water. A steep ride over sandstones and some oolitic beds brought us to the summit. So far as we could see from there, no flowing water existed within a radius of many miles. In the distance several lakes appeared, but even with the aid of our field-glasses we could not determine whether the appearance was not the result of mirage. Far below us the pack-train slowly plodded along on an old road leading southward. Essex Mountain was too far off to be reached that day, and the prospect of obtaining water was by no means promising. Having completed our station, we led the animals down a steep slope, over very much disintegrated sandstones and marls. Sinking into the loose material deeply at every step, the downward trip was fatiguing both to man and beast. Tracks of antelope became scarcer as we receded from the Sweetwater, a feature that did not tend to encourage our hope for water. About sundown we found camp, located several hundred feet above the valley on the slope of a ridge. Here a small spring was found, which, by artificial enlargement, furnished a sufficient supply of water. Wood was obtained from some groves of quaking asp, and we felt thankful for so comfortable a camp. One objection to it existed, however, in the abundance of woodticks. Crawling in under the clothes these animals firmly fasten themselves in the skin, producing most disagreeable sensations, and sometimes causing small wounds that are slow to heal.

Our course still lay southward. During the day following we made several stations, travelling in the direction of the groups of basaltic hills mentioned in previous pages. We rode over sterile country all day long, nothing occurring to relieve the monotony save the appearance of some antelopes. Numerous small, gray birds (sage-sparrow) enjoyed themselves in the sage-brush, probably deriving the water necessary for their sustenance from the copious dew. In watching them we observed that frequently they would fly up directly in front of the mule, as if suddenly surprised, and in danger of being trodden upon. We found, however, that they quietly slipped out of their nests at our approach, ran swiftly along the ground, dodging behind brush and grass, and did not attempt to fly until observation directed upon them could no longer reveal their habitations. This same sense of deception, due to the instinct of self-protection, we noticed in many other birds of similar regions.

Having followed the trail of the pack-train until nearly dusk, we found that it suddenly turned in the direction of Mount Essex, which had been passed during the day. After a tedious ride of five or six miles through loose sand, we found ourselves once more at our old camp at the base of the mountain. The lake which we had seen two weeks ago had lost at least 8 inches by evaporation, and the spring was no longer as large as it had been.

On the day following, *June* 17, we continued our march southward. Ahead of us were several basaltic hills, and we hoped to find both water and grass there. A ride of 16 miles along the old wagon-road which we had been following brought us to the north base of a long,

narrow basaltic ridge. A small alkaline spring and good grass were found there. Although the march had been a short one, it was fraught with fatigue, having led in great part through deep sand. In among the rocks we found a beautiful spring of clear, cold water. That this resort was well known to the game of that region we had ample opportunity to observe. The slope of the ridge was covered with a scattering growth of quaking asp, and from several small groves we "jumped" black-tail deer (*Cariacus macrotis*). As will be seen from the geological report following, this region was one of considerable interest (Stations 25 and 26). Here the basaltic lava has found its way through Tertiary strata and, flowing over a considerable area, has indicated its points of ejection by crater-like cones. Protecting in part the softer sedimentary strata, the basalts have at some places been undermined, and falling down, have given rise to the formation of vertical rock faces.

Our course during the next day lay through narrow cañons and across steep, Tertiary bluffs. The character of the rocks there and the small amount of precipitated moisture, rendered it highly improbable that we should find water. In the course of our ride we struck the old road which has been designated as Evans's route, and followed it. Eventually this led us to a small creek, which still contained stagnant pools of water. Fearing to risk any further chances we made camp. As we approached toward the south the character of the country became more and more that of a desert. Green vegetation disappeared altogether, crowded out by sage-brush and cactus.

Next morning we started early and made a number of stations, while the pack-train continued along the old wagon-road. After crossing several ridges we saw before us an apparently boundless plain, perfectly level and absolutely unbroken. No chance appeared for the finding of either water or grass, and we determined to march toward the railroad as rapidly as possible. Accordingly our course was changed. We soon reached a perfectly flat basin, one which had probably formerly contained a lake. At its northern end the color of the bare soil was a dazzling white, reflecting the hot rays of the sun. Gradually this changed into pink, and eventually into a bright red. Hour after hour we rode over the bare, compact ground, no change in scenery or character of the soil taking place. To the southward was a prominent butte, Eagle Rock, and about 6 miles beyond that stretched a long row of regular bluffs. Ascending the butte in question at five o'clock in the evening, we saw before us the narrow line of the Union Pacific track. About 4 to 5 miles distant was the building of Red Desert Station. As an illustration of the remarkable purity of the atmosphere it may here be mentioned that at this considerable distance we were able to count the number of windows in the building without the aid of field-glasses. A ride through sage-brush and some grass, made more agreeable by the prospect of no "dry camp," brought us to the station. Thanks to the courtesy of the agent, we were enabled to use the water there obtained by means of an artesian well. After having marched for more than 40 miles in a burning sun, over dry and dusty country, the mules fairly fought for the water that was dealt out to them in tubs. The entire region north of this portion of the railroad is very dry, water only being found at rare seasons in small pools or temporary runs. Absence of game, and even of the smaller, burrowing animals, proves the extraordinary sterility of the region. Red Desert, the name which has here been applied, is well chosen, for few spots so thoroughly realize the conception of a desert as this. All the information we could obtain regarding this locality con-

firmed our own opinions as to its character, and we determined to follow the railroad for a short distance before striking northward again.

On *June* 20 we left Red Desert and marched eastward to Wash-a-kie Station. An addition was here made to our party by the acquisition of a dog. Though an unimportant member in himself, he subsequently showed such remarkable endurance in travelling and mountain climbing that he is well worthy of being mentioned.

FROM THE UNION PACIFIC RAILROAD TO CAMP STAMBAUGH.

Wash-a-kie Station is named after the venerable head chief of the Shoshone Indians, who has always proved himself to be a staunch friend of the white man. Past this station leads the trail utilized by the Northern Colorado Utes in making their annual visits to their friends and allies, the Snakes. On June 21 we started upon this trail, travelling northward. It led over several ridges until finally one main ridge was reached. While the pack-train had disappeared from my sight, at a time that I was about 3 miles east of it, I had occasion to observe a very striking mirage effect. Where the train was at that time I did not know, having left it a couple of hours before. Looking westward I saw the procession of riders and pack-mules slowly filing along the summit of a high ridge which gently sloped to the west. Wishing to satisfy myself as to the truth of this appearance, I used my field-glass. Although the distance at which the party appeared to be was about 3 miles from my point of view, I could distinctly recognize each man. The forms seemed slightly distorted, but not more so than might be expected at that distance on a hot day. Finishing my examinations where I was, I, several hours later, proceeded to find the trail and follow it. No trail was to be seen on the ridge. Not until I had descended on its western slope about 800 feet and ridden more than a mile, did I find the trail at a place where it would have been utterly impossible for me to see the men and animals some hours before.

On our march along the trail we passed a number of alkali-flats. During the wet season these are filled to a shallow depth with bad-tasting water, but at the time we passed them they were perfectly dry and hard. From a distance they may easily be mistaken for water. The hot air ascending from them produces a reflection of light, which, in turn, raises the level of the bed, so that, apparently, grass and other plants can be seen as if growing above the water-level. This particular feature adds very much to the deception of a mirage. Along the trail we found the remains of lodge-poles, and at several places, where there had been water early in the spring, were remnants of old camps. Ascending a high divide, we saw, about 8 miles from us, a large sheet of water. So far as we could determine, the trail headed directly toward it. So often, however, had we been deceived that we scarcely hoped to find our expectations realized. About sundown we obtained a near view, however, and saw a large lake, just beyond a belt of sand-hills. Upon reaching it we found that Indians had camped there only a short time previous, and we occupied the spot which they had abandoned. Antelopes and wild water-fowl were very plentiful near the muddy-looking water. Although it contained a considerable amount of alkali, and had to be cooled before being fit to drink, citric acid rendered it quite palatable.

For two days we remained encamped at this lake, making excursions from there for the purposes of topographical and geological work. We found that instead of a divide between the waters of the Atlantic and Pacific Oceans, there was here a large tract of neutral ground. Tem-

porary creeks and streams all emptied into "sinks." At times these sinks contained water, as the lake we were camped on—Trail Lake—but mostly they were perfectly dry. This feature is one of great interest, and will be discussed more fully in the geological report.

Upon examining the surrounding country, we saw that for some time at least we might obtain water from various such lakes scattered through it. On June 24 we broke camp, and, proceeding in a northwesterly direction, reached another body of water about 12 miles distant from the first. On the route we noticed the continuation of the sand-masses which we had first observed near Mount Essex. The character of the country was that of a barren, sterile plain. Sage-brush, cactus, and very scanty grass comprised the entire vegetation. For several weeks we had no fire except that furnished by sage. Huge bushes, sometimes more than a foot in thickness, were met with. They afford a very hot but short fire, and not unfrequently impart a bitter taste to whatever is cooked by their aid.

Next morning we moved in a northeasterly direction into a long valley, where a number of small lakes were found. Antelopes became very abundant, having begun to run in small bands. On that day we found the first tracks of buffalo. Coyotes, lingering around and rapidly disappearing upon our approach, gave evidence of the presence of large quantities of game. Wild geese (*Branta Canadensis*) and ducks (*Fuligula sp.*) were found in the lakes, but proved to be poor marks for rifle-bullets. Mosquitoes seemed to revive from their winter's sleep, and wood-ticks every now and then made themselves felt.

To the northeast were a number of high, prominent bluffs, which we desired to visit. Accordingly camp was broken on the 26th of June and moved up the valley. We found a small spring containing good water, and an ample supply of grass in its vicinity. Buffalo-chips served as fuel. Ascending a plateau-like ridge, we rode along this to reach the points which we intended to utilize as stations. Numerous bands of antelope were met with. They would first quietly study our appearance, and then scamper off over the bluffs. Sandstones and shales, belonging to the Tertiary formation, composed the hills, and by their ready disintegration rendered the isolated points easy of access. On that day we found the trail of our main triangulation party, which had passed there more than a week before. Looking northward from our elevated points we could see the granitic hills of the Lower Sweetwater, the distant Wind River Mountains, and, as a dim, cloud-like form, the mountains of the Bighorn Range. On the south side the white alkali flats, some of them containing water, were very prominent, and beyond them stretched the long belt of yellow sand. Monotonous repetitions of parallel bluffs produced the impression of uninterrupted plains, and offered little that was inviting.

Leaving our camp on the spring on June 28, we rode in a northwesterly direction, expecting to camp within some granitic hills south of the Sweetwater. A small band of stray cattle, which at first our imagination transformed into buffalo, indicated the vicinity of white man's habitation. We found, upon reaching the granitic area, that this was a continuation of the metamorphics observed southwest of Camp Stambaugh. As farther down on the river, so here the granitic hills exhibit striking characteristics. They are very rugged, hard to climb, and almost entirely devoid of vegetation. A few scattering pines manage to subsist on the east side in crevices among the rocks. Water was plentiful, occurring in small running streams.

Early on *June* 29, just as the mules were being packed, we were sur-

prised by a short snow-storm. This was followed by a most violent gale of wind, which lasted nearly all day. The cold air, sweeping down from the neighboring mountains, condensed the suspended moisture of the atmosphere until this was exhausted or carried farther by the force of the wind. After a disagreeable ride, almost blinded by sand, we found shelter in a narrow cañon of Carboniferous limestone. During the entire day it was impossible to set up the instrument. We found the region sufficiently well watered, and had within a day left Tertiary formations for some of the oldest of the region. We found a number of small cañons in these limestones, caused probably by seismic action rather than by erosion. While the pack-train descended this creek, upon which we were camped, to its junction with a direct tributary of the Sweetwater, we rode northward. Passing first over massive hills of Carboniferous strata, we soon reached the late Tertiary deposits composing the Sweetwater group. Antelopes were very abundant along our route, occurring in bands of several hundreds. Shortly after noon we reached the river. Its southern bank was swampy, and the river-bottom contained much quicksand. Following it downward, everywhere surrounded by tracks of buffalo, we reached a tributary from the south. This we ascended, and finally found camp. Very little or no timber is to be noticed on this portion of the river, willow-brush, sage, and grass comprising the most prominent part of the vegetation. The fall of its tributaries here is but slight, and their water, in consequence, is muddy and alkaline. Easy decomposition of the surrounding strata furnishes a never-failing supply of the various salts, and often the solution is little less than a saturated one.

July 1 dawned frosty and very cold. Even overcoats could not afford sufficient protection against the low temperature and driving wind. After doing some work northeast of camp, we rode on to the Sweetwater, where camp had been made. Driftwood furnished the material for fire, and proved to be a pleasant variation from sage. On the north side of the river we found the old emigrant-road, which thirty-five years ago was a favorite route for overland travel. We had then fairly entered the region which in 1842 was traversed by Frémont's small party. Following this road up stream we met with many indications of travel done during an "early day." Saint Mary's Station, a well-known landmark on the river, is situated about eight miles above our camp of July 1. Nothing but ruined walls remain to indicate the spot which at one time was the scene of active life. Indians and the railroad have produced isolation of this region, which once bid fair to have a prosperous future. A few miles above Saint Mary's, the road leaves the river, winding upward among steep, rocky bluffs. Looking down toward the river we there found it enclosed by steep cañon-walls. Rising at a very high angle from the bed of the Sweetwater, metamorphic, and in part sedimentary, rocks form an impassable cañon. The walls are about 600 feet high. Scattering spruce trees and small groves of quaking asp find sufficient soil there to thrive in crevices and on the small talus near the base. In the bottom of the cañon the river rushes along over numerous bowlders that have fallen from above, forming a succession of foaming rapids. Above the entrance of this narrow chasm it once more runs smoothly, almost lazily, through its channel fringed with willow brush. Isolated cottonwood trees and some quaking asps impart a very pleasing aspect to the valley, as seen from above.

Following the wagon-road, we found ourselves again within the metamorphic area, crossing a number of small creeks which flowed into the Sweetwater. Numerous antelopes and large flocks of sage-hens (*Centro-*

cercus urophasianus) enlivened the route and furnished fresh meat for our larder. On Strawberry Creek, a small stream that is well known to gulch-miners of that region, we made camp. A ride of about 10 miles more brought me into Camp Stambaugh, where I received a large mail and despatched one of respectable proportions. July 3, we marched into the post, and once more encamped near our hospitable friends. At that time the post presented a lively appearance, due to the passage of many emigrants bound for Wind River Valley or the Bighorn Mountains. Mounted on horses, mules, and donkeys, or packed into wagons, men, women and children travelled cheerfully forward to meet a fate which, whether good or bad, the future must decide. The wonderful elasticity of the western pioneer, and miner, the indomitable energy, and the desire for new, unoccupied fields of labor are qualities that render the nation deeply indebted to them. Though many may perish on their way toward opening a new district to civilization, others follow in their wake, and, eventually, savage as well as natural obstacles must yield to the will and energy of the white man. Individually, often worthless, these pioneers, as a class, fulfil their mission, indifferent whether their reward be riches obtained by a lucky "find," or the scalping-knife.

July 4 was spent in reprovisioning our party, and, appropriate to the day, we undertook to resight our rifles. While doing this we kept up a cannonade that would have done credit to the most patriotic party. During the day I visited a number of mines in the vicinity. After an evening pleasantly spent in the company of the post officers, and writing a few letters by the camp-fire, we turned in, to commence on the morrow the exploration of a region that promised to us less hardships and greater reward in the discovery of new and interesting features.

FROM CAMP STAMBAUGH TO CAMP BROWN.

Accompanied by Lieutenant Cole, of Stambaugh, we set out on July 5 on the road toward Camp Brown. Two miles from Stambaugh we passed through Miner's Delight, a small settlement dating back to the time of the Sweetwater mining excitement. But little work is being done there now, although the ground shows that at one time many hands were busy in extracting gold from the gravel. Beyond Miner's Delight the descent into the valleys of Wind River drainage becomes very rapid. By following the stage-road to Camp Brown we pass through Red Cañon. This is cut deeply down into the red Triassic sandstones and shales. On the right-hand side we see a steep wall of the bright-colored material, while the valley exhibits the beautiful color of rich verdure. Several small farms have been located there, and furnish good results to their owners. To the left the Wind River Mountains rise 7,000 feet above the valley. From the latter the main peaks are not visible; only the higher foot-hills can be seen. Descending rapidly we reach the crossing of the Little Popo-Agie River. Looking up stream we perceive a very fine narrow cañon through which the stream rushes with great violence. Vertical walls of Carboniferous limestones rise abruptly from the river bottom, forming a narrow, irregular fissure. In passing from the Sweetwater to Wind River drainage a radical change of the scenery is noticeable. The lowest foot-hills are formed by old sedimentary strata, sloping down steeply toward the valleys. Cañons are cut through the strata, and from them the streams emerge into broad, fertile valleys. On the Little Popo-Agie we found several farms. One of them belongs to Stambaugh, and a few men employed there are able to cultivate a quantity of land which yields ample results. Mr. Faris has been farming at the

same locality for a number of years. Several times straying parties of Sioux have interfered with his progress, but he has always escaped uninjured. Both the soil and the climate are advantageous to agricultural pursuits. We camped near Faris's ranch, and had the enjoyment of entertaining innumerable mosquitoes. After leaving comparatively high altitudes, the temperature of a region about 3,000 feet lower became very oppressive. On the day following Lieutenant Cole left us to proceed to Camp Brown, and we marched in a southeasterly direction, to reach Sheep Mountain. On the way Clymer was attacked violently by mountain fever, the result of changes of elevation and atmospheric conditions. Sheep Mountain is a high, comparatively isolated hill, composed of quartzitic material. Timber and water are abundant there, but are rendered less enjoyable by the presence of innumerable horse-flies, cattle-flies, and mosquitoes. Game appears to be abundant, and rattlesnakes may very often be met with. Camps made in that vicinity were pleasant with the exception of the insects. On the 8th, our patient was able to travel to Camp Brown by stage, where he received medical aid and the courteous attention of the officers. On that morning seven of our mules strayed off. Owing to the hard soil, and to the fact that a great deal of cattle was scattered over the country, it became almost impossible to track them. On July 10 I rode to Camp Brown, having examined the regions of the Little Popo-Agie. That same morning the lost mules reached Stambaugh, where they were recovered again. Two days later camp was moved to the mouth of Twin Creek. This is located about 4 miles below Faris's ranch. At that point the valley of the stream widens considerably, affording excellent grazing for stock. After that it narrows somewhat and is covered with brush. On the northern slope of a steep bluff at that locality we found what the inhabitants call "the tar-spring." This consists in a spring of petroleum, which slowly oozes out of the rocks. During the hot season it liquefies and flows down stream for several hundred yards. Judging from the thickness of the oil-deposit the flow of this spring must date back for a great many years. The surrounding country is very much broken in that region, cut into narrow ridges, and deep, waterless cañons. Triassic sandstones, violently disturbed from their original places of deposition, comprise the bluffs. Leaving the Little Popo-Agie the road leads in a serpentine course to the settlements on the Big Popo-Agie. An old trail cuts off about 4 miles, and passes through a pleasant country. A stream (Willow Creek) is crossed about half way to the town of Landers. This settlement is located near the Big Popo-Agie, a swift stream of considerable size issuing from the mountains into a broad valley. Many farms are cultivated there and yield good crops. So long as no Indian raids occur, the settlements will probably flourish. The increasing number of settlers daily lessens the danger incident upon invasions, and it may be hoped that they will permanently escape danger from that source.

On *July* 13, camp was made on the North Fork of Popo-Agie. There, for the first time, we met an Indian camp. For a small amount of sugar some very fine trout were obtained from them. From the crossings of the stage-road these streams flow in broad valleys until they join the Little Wind River. On the day following, the party marched over a rather monotonous section of country into Camp Brown, where I rejoined it. Capt. J. Mix, the commanding officer, extended all aid in his power to us, and afforded us material assistance.

"Old Camp Brown" was established June 28, 1869, as Camp Augur, where now Landers City is, but later was moved 15 miles farther north. The post is named after Capt. Frederick Brown, of the Eighteenth in-

fantry, who was killed by Indians at Fort Phil Kearney December 21, 1866. At present the post is situated on the Little Wind River. Its location is a very beautiful one, on the banks of a swift, wide stream, densely timbered with cottonwood and willows. The buildings of the post are rather cramped, but at the time of our visit improvements were being made under the direction of the commanding officer, which will, in a measure, relieve the inconvenience incident upon its original construction. With reference to the Indians, the location of the post is well chosen, furnishing a good key-point to any movements that may be made against the settlements and mining districts. Telegraphic communication has been established with the railroad as far as Stambaugh, and from there a messenger can soon reach the more northerly post.

In the vicinity of Brown are two features which have for a long time attracted the attention of travelers. One of these is the "hot spring," and the other is a petroleum spring similar to that on the Little Popo-Agie. Upon occasions of state the spring is set on fire and illuminates the entire region. For invalids, particularly rheumatics, the hot spring is a desirable resort. It is located about 2 miles west of the post, and shows a temperature of about 108° F. Accommodations have been prepared for the bathing of invalids and others. The water is mineralized and, owing to its high temperature, exhibits very beneficial results. In the geological report a more detailed account of the various features of this spring will be found.

Within a few miles of the post the Shoshone Indian agency is established. At the time of our visit but few of them were there, nearly all being off on hunting expeditions. Wherever we met Indians belonging to this tribe, we were on very good terms with them. They are thoroughly characteristic in their dress and habits, and favorably compare with their nearest allies, the Utes.

From Camp Brown a fine view of the Wind River Mountains presents itself. The foot-hills shut out a large portion of the picture, but enough remains to show the beauty of the range. In the distance the outlines of the Bighorn Mountains can easily be distinguished. Some very prominent forms are visible there, appearing to the wandering miner and prospector as the legible writing showing to him the promised land.

FROM CAMP BROWN TO CAMP STAMBAUGH.

On *July* 15 we left Camp Brown and marched westward toward the mountains. It was our intention to return to Stambaugh, traveling along the eastern slope of the range. From what we had heretofore seen, we came to the conclusion that the highest peaks could not be ascended except from the west slope. This we found to be the case. We had been warned that mosquitoes and horseflies would greatly trouble us in the mountains, and we soon learned that the descriptions given fell far short of the reality.

The Wind River Range may here be appropriately divided into three distinct chains. The highest one, sloping directly westward, is inaccessible from the east. Then follows a chain of high foot-hills, reaching above timber-line at some points, falling off steeply toward the east. Beyond this, forming a transition into the low country of the Wind River drainage, is a long row of hog-back-shaped hills of large proportions. These are composed of the older sedimentary rocks, and rapidly slope down into the valleys. Streams cut through them, forming steep, sometimes impassable, cañons.

Upon starting out from Brown we followed an old wood-road up to

the summit of one of these hills, making a station very near the northern limit of our district. From here we obtained a good view of the mountains. Before us lay a perfect wilderness of bare rocks on the summits and slopes of ridges which lead up toward the highest points of the foot-hills. Numerous small lakes and foaming mountain-torrents, with very picturesque cascades, kept up an incessant roar. Wherever soil had formed, dark spruce and fir timber densely covered the ground, fringed, lower down, by the lighter colored aspen. After the desert-like country we had traveled through, this region appeared like a small paradise, and the prospect of wood and water permitted us readily to forget the annoyances that awaited us in the shape of mosquitoes and horse-flies. Descending on a steep grassy slope into the depression between the outer hills and the base of the foot-hills, we made camp in a very pretty grove of pines and quaking asp. A deer, too curious for its own welfare, was arrested in its earthly career while inspecting our camp. The cool mountain air brought us refreshing sleep in spite of the numberless mosquitoes that kept up a monotonous concert during nearly the entire night.

On the day following we traveled parallel to the range, in a south-easterly direction. Stations were made on the outlying hills, and camp was moved up higher into the mountains. Instead of sinking into sand, as we had done a few weeks before, our animals were now obliged to plod through swamps. Nearly frantic from the bites of hundreds of horse-flies, they dashed their heads and bodies into small trees or branches of larger ones utterly regardless of rider or pack. During the day we crossed several small streams, tributaries of the North Fork of the Big Popo Agie. On some of the streams we found very beautiful "parks" containing some game. Most of the latter had sought shelter elsewhere to escape from the flies. Within the dense timber they were less troublesome, but near any body of water they came in thick swarms. We were obliged to keep our camp entirely enveloped in smoke, but we soon found that even this method did not afford protection. Apparently the mosquitoes enjoyed the warmth and took advantage of it. By evening the animals became so nervous from the constant vexation that often the snapping of a twig would start them on a small stampede. Rubbing their breasts and necks with grease seemed to be the best remedy against the severe attacks from these insects. A weak solution of carbolic acid was found to answer very well until evaporated.

On *July* 17 we started early to march higher up into the mountains. We had been informed that it was impossible to cross the North Fork within the mountains, but we proposed to make the attempt. A ride along a dim Indian trail led us through a very pretty "park." Gradually rising, it stretched along a clear mountain brook for 5 or 6 miles. On either side of the open space was dense pine and spruce timber. About ten o'clock we reached the summit of the ridge beyond which the North Fork rushed through its cañon. A most discouraging sight presented itself to our view. Very steeply inclining, the slope led down to the stream. Rocks, "down timber," and marshy places covered the slope. Vertical walls of, sometimes, 50 feet in height threatened serious consequences to any animal that might slip on the treacherous ground. Below, the stream rushed along, forming a continuous series of rapids. On its other side a slope led upward the exact counterpart of the one we would have to descend before reaching the river. After selecting the best route we led our mules down, winding in and out of rocks, jumping logs, getting mired in swamps, and having hard work of it generally. In due time, however, we reached the bottom of the

cañon and found that all the animals had escaped without damage. Owing to the treacherous character of the bank, it became a matter of some difficulty to find a ford. Eventually we determined upon crossing in an eddy. At that place the water was deep enough for the smaller mules to swim, but the current was not very swift. All reached the opposite side in safety. The ascent was more difficult than the descent. It was necessary to move logs, cut away brush-wood and form a kind of road over the large masses of broken rock-bowlders. At some places the grade was very steep, so that the mules could only overcome it by a run, after which they stood still above the first surmounted obstacle, panting, and blocking the way for the next comer. After a couple of hours of climbing we reached the top of the ridge. Here we found that a sort of table was formed, from which, some distance beyond, the higher ridges rose. A lake of considerable size gave a very pretty character to the view before us, and numerous fresh deer and elk tracks showed that game appreciated this locality. We encamped near the lake during a driving rain-storm which had thoroughly soaked us before we had a chance to get dry.

Camp remained stationary the next day, while we examined the high ridges on either side of us. Ascending the steep rocky slope to the west of the lake we reached timber-line after a climb of about 1,000 feet. Above that we found an abundance of snow. From the summit here we obtained a remarkably fine view of the main chain of the Wind River Range. With one exception—the Quartzite Mountains in Colorado—I have never seen so rugged and precipitous a mass of mountains in America. Enormous vertical faces fronted to the east absolutely cutting off any approach from that side. Immense fields of snow still remained in the deep recesses scarcely ever touched by the rays of the sun. Avalanches of snow and rocks had rushed down from the steep slopes for several thousand feet, carrying before them the timber. Now they lay in masses piled up in chaotic confusion. Fissures which had rent the rocks extending, for hundreds of feet and filled with glistening snow, presented a weird, wild scene. Save the rushing of torrents leaping over the rocks no sound there broke the stillness. A small band of mountain sheep making their appearance on the crest of the ridge reminded us of camp, and one of them soon lay bleeding on the snow. Returning again to camp, the evening was spent in vainly trying to escape the mosquitoes.

July 19 we descended the ridge south of us, and, after a march of about 18 miles, encamped on the Big Popo Agie. In the valley of this river we crossed a wagon-road leading from the timber districts down to the settlements of Landers. Near our camp we found the stream flowing in a series of rapids over huge bowlders within a narrow cañon. A few hours' fishing in some small pools, caused by a partial damming of the water, furnished us with a good mess of trout. From that point upward the Popo Agie has the character of a mountain torrent. Its very considerable fall and the character of its beds produce this. About a mile and a half below our camp the stream suddenly sinks, remaining entirely hidden from sight beneath large rocks for some distance. Upon emerging it soon attains the same size as at the place of disappearance. Probably a subsidence of some subterranean cave and the subsequent filling in of loose rocks have produced this effect. Early the next morning we crossed the river near an abandoned log-cabin, and made some stations on the outlying sedimentary hills. We had now reached the lower country again, but determined to go higher up into the mountains once more, so as to finish our work in the southern end of the range. Travel-

ing through several very pretty, well-watered valleys, we finally took to a ridge leading up to the highest points of the foot-hills or second chain. Large timber densely covered the summit and slopes, but progress was made easy by the absence of undergrowth and loose bowlders. As we approached timber-line, however, this changed. Angular fragments of rocks covered the ground, and the timber, obtaining but a poor hold in the small patches of soil occurring there, had succumbed to storms, and now lay piled up in every direction. Riding became impossible at some places, and as it was getting late in the day we encamped at timber-line, about 10,800 feet above sea-level. Even here we could not remain unmolested by mosquitoes, but had to "build smokes" to keep them off. Before dark we made a station on a peak about 800 feet above timber-line. From there we saw that we were near the southern end of the range, and obtained an extensive view into the low country southwest of us. We noticed large numbers of the little "mountain-rat" (*Lagomys princeps*) or marmot. Their shrill piping note, not unlike the chirp of a squirrel, was heard all over the hill, and the graceful little animals came out of their rocky homes to look at us with mingled surprise and curiosity. A very cold night, with ice in the water by morning, recalled to us the amenities of lower elevations. On the following day we traveled toward the southeast, passed over a high dividing ridge, and found ourselves on the drainage of Sweetwater River. We had thus crossed the southern end of the range, and found ourselves within 20 miles of Camp Stambaugh.

July 22 we started early, and traveling through a very pretty series of valleys and across low ridges, we reached the stage-road near Atlantic City. Scattering timber in the gulches and a few pines along the ridges give the region a very pleasing appearance. Hay is cut in some of the meadows, which is furnished to settlers and to the military posts. By afternoon we reached Stambaugh, where we found Clymer fully recovered from his attack of fever, thanks to the kind attentions he had received at the hands of the officers and to his good constitution. Although we had been absent but a short time on our last trip, the large number of incidents that had been crowded into each day made the time since our last departure from the post appear very much longer. Having arranged whatever would occupy our time during the same day, we were prepared to leave the post on the next morning, once more having the number of our party complete.

FROM CAMP STAMBAUGH TO SNOW PEAK AND RETURN.

July 23 we left Camp Stambaugh, intending to survey the western slope of the Wind River Mountains. Marching along the stage-road, we passed through Atlantic and South Pass cities, camping a few miles west of the latter. On the day following we traveled up one of the tributaries of the Sweetwater, through a heavily-timbered region. Willow grouse (*Lagopus leucurus*) were quite plentiful, and our stock of provisions was enlarged by the acquisition of a black-tail deer. We made camp near the base of the highest peak, at the southern end of the range. To our sincere satisfaction we found the mosquitoes and flies less troublesome on this side of the mountains, owing, probably, to the fact that they were here more exposed to wind. A very pretty little valley contained a portion of the Sweetwater, which rises higher up in the mountains. Rich grass and comparative freedom from molesting insects were of good service to our animals. Within a small grove of slender pines we had pitched our tents, enjoying the comfort of a good camp. Remnants of a brush-hut and bones of deer, mountain-

sheep, and other game indicated an old camp of hunters who had evidently met with good success.

On *July* 25 we started at sunrise to climb the high peak before us. A ride of about 8 miles led us, gradually ascending, to its immediate base. The timber covering the ridge we rode along on was spruce, of singularly regular growth and free from under brush and fallen trees. As we approached timber-line, however, the remnants of former glaciers and the accumulation of avalanchial drift rather impeded our progress. Huge bowlders were piled on top of one another, forming, at times, dams behind which small lakes had collected. Near timber-line we came across a band of mountain-sheep (*Ovis montana*) numbering over 100. Old rams, ewes, and lambs were all represented. Upon our approach they scampered off in a great hurry, but not before some had been secured. Tying our mules securely to some dwarf pines (*Pinus contorta*) growing at the extreme limit of timber we proceeded to ascend the rocky slope on foot. Here again we met with a small band of sheep. Frémont, in his report, frequently alludes to the large numbers he saw in this range during his visit 35 years ago. He mentions them either as "sheep" or "goats." The Rocky Mountain goat (*Aploceras montanus*) is a totally different animal, occurring farther northwest. We found that the sheep at this season of the year had not yet shed their winter coats. Frequently the report that these sheep were covered with "wool" has been regarded as one evolved entirely from the hunter's own consciousness. Upon this occasion we found that the wool which they had certainly carried during the winter was just shedding. A growth of stiff hair, about three-quarters of an inch in length, was nearest to the skin, and upon this we saw a layer of fine, light-gray wool, about half an inch in thickness. It was at the time gradually being pushed off. On some portions of the body the single hairs of wool could be directly traced to the skin, not having as yet severed their connection. We found this not only on a single specimen, but on all that were killed. So far as we could determine, upon the rather hurried glimpse we had of the entire band, all its members were in the same condition as regards covering.

Climbing over rocks and isolated patches of snow, we finally reached the summit of the peak. By barometric measurement it was found to be 12,700 feet high. By some of the settlers and on some maps this mountain is designated as Frémont's Peak. Inasmuch as this latter is over 40 miles farther north, however, the name cannot stand. Appropriate to its location and the pleasant remembrances we carried with us from the neighboring post, we named this mountain *Stambaugh Peak.*

July 26 we broke camp, and, after crossing the Sweetwater, ascended a high ridge. Here we found very fine timber, with grassy soil under foot. Before us lay the massive form of a mountain that has received the name of *Snow Peak.* While riding along in the forest we met our first band of elk (*Elaphus Canadensis*). One succumbed to several rifle-balls. The horns were still "in velvet" and could not be preserved, but the meat was much admired. Advancing toward the downward slope of the ridge, we saw beneath us a large lake of remarkable clearness. Reflecting the rugged hill-sides surrounding it, the varied coloring presented by bare rocks and dark spruce timber allowed but a small space to remain for the image of a blue sky, with its white, floating clouds. From where we stood it appeared impossible to descend the slope toward the lake, and equally impossible to continue forward. We decided upon the former. Clearing away timber and brush, making roads over the vast fields of angular rock-fragments, and sliding the mules down over

steep, smooth rocks *in positu*, we reached the lake after several hours of hard work.

Looking up along the route which we had just traveled, it seemed incredible that any animal larger than a deer could accomplish what our mules had done. From below we could see nothing but a mass of steep rocks, one apparently piled on top of the other, with a scattering growth of timber intervening. Narrow ledges, not visible from below, had been the means which made our descent feasible. After a certain distance had been traversed, it was no longer a matter of choice whether we would go on or not, as a return by the same way would have been beyond our power. We encamped at the lake, in the shelter of a grove of spruce-trees. Not far from our camp we found that of two fishermen, who gained a well-earned livelihood by catching fish in this lake—*Barret's Lake*—and selling them at the settlements. They had constructed a raft, upon which they pushed out into the lake, and then fished in deep water with still bait. Two of us accompanied them, and an hour's fishing furnished us with over a hundred pounds of very fine trout, weighing from three-quarters to a pound and a half each. It seems that this lake is literally crowded with fish, and their rather emaciated condition indicated that there might be more than could well be sustained there. In this connection a fact may be mentioned that, surprising as it may seem, is fully borne out by numerous observations: In the head-drainage of the Sweetwater not a trout can be found, while in that of Green River, as well as Wind River, they occur in large quantities. Why this should be so is not very apparent. The streams, near their headwaters, or rather those of their tributaries, are but a few miles apart. They rise in the same lithological formations, and eventually they flow through the same. All of the streams under consideration obtain considerable size while yet within the metamorphic area. In both the Green River and Wind River drainage, trout are caught long after the streams have left the metamorphics. So far as can be determined without detailed examinations, the vegetation on all these streams is essentially the same, and no industrial works are extant that might adulterate the water of the Sweetwater. Wherever a stream of any size presented itself we fished, and, unless falls or large cascades prevented the rising of the trout, they were found in all creeks excepting those which flow into the Sweetwater. No cause that is apparent to me can be assigned for this peculiar distribution.

Mr. Fosher, one of the fishermen, decided to accompany us on the following day in our ascent of Snow Peak. It appeared to be the highest peak of that portion of the range, and we promised ourselves a very extensive view from its summit.

On *July* 27 we made an early start, expecting a long foot-climb. Riding up the narrow cañon of the stream which emptied into Barret's Lake, we gradually approached timber-line. The ground was frozen hard, and we rode in safety over swamps. Small lakes, shallow, as a rule, were almost entirely frozen over. On either side of the narrow, partly-timbered valley, precipitous walls of metamorphic rocks rose up to a relative elevation of more than a thousand feet. Exposed rocks on the ground showed very thorough effects of glaciation, and rows of erratic bowlders denoted the course of former glaciers. Slowly making our way in the valley, which gradually grew narrower as we approached the immediate base of the mountain, we encountered large masses of snow. Upon it we found the tracks of what must have been a bear of very large size. A porcupine (*Erethizon epixanthus*), having shed its quills, was shot near timber-line. As the snow was comparatively firm

we could safely ride over it, although at many places it was over 20 feet deep and would have hopelessly sunk animal and rider had the hard surface-crust broken. At one place my mule broke through, and had she not been near the edge of the snow-bank it would have required hard work to get her out. As it was, she struggled for a foothold and was gradually dragged to firmer ground by the lariat. Having ridden up a very steep, rocky slope, until we reached an elevation of about 12,500 feet above sea-level, we secured our animals to some rocks on the top of the ridge and commenced the ascent of the peak on foot. Pausing a moment to survey the ground before us, we found ourselves on a sharp ridge falling off steeply toward the northeast. Our position was about west of the peak. Two thousand feet below us were several small lakes, still frozen over, showing a light-green color, which strongly contrasted with the dark shade of surrounding spruce-timber. Before us lay a steep slope, leading from the peak down to these lakes, about 4,000 feet in length and 1,000 feet wide. This was covered by one field of snow. From what we there saw, we estimated that the thickness of this snow mass must be over 100 feet at some places. In order to make the ascent we walked across this steep snow-bank in a line slightly slanting upward. Hard and crisp as it was, the foot had to be firmly set down so as to retain its hold. Once in a while one of the party would slip and slide down on the smooth bank some distance before he could stop himself. Having traversed the entire width of the field, we took advantage of some rocks projecting from a small spur, and climbing upward partly on them, partly on the snow, we finally reached a point from where the ascent became more gentle. Before eleven o'clock we reached the summit of the peak. There we found a monument built by Mr. Wilson, the chief of the main triangulating party. He had ascended the peak about a month before us, for the purposes of his work, but was forced to abandon it on account of a storm. A few days later he made a second attempt, and, although suffering severely from the cold, succeeded in accomplishing his work. At the time of our ascent it was cold, the thermometer standing at 44° F. Added to this was a sharp westerly wind, against which our coats afforded no protection. Our dog had faithfully accompanied us to the very summit, 13,400 feet above sea-level.

The view from this peak came fully up to our expectations. Looking toward the northwest we saw the numerous jagged peaks of the Wind River Range. About 35 miles distant was one apparently higher than those surrounding it. This was Frémont's Peak. Rising above all near it, this mountain is a fit monument to the energetic explorer, who, in 1842, when the entire country was but an unknown and dangerous wilderness, unfurled the American flag on its summit. To the west the mountains of this main chain present more accessible slopes, while their eastern faces are exceedingly precipitous. From the top of Snow Peak a stone could be thrown, eastward, that would fall fully 2,000 feet before striking. Surprising to us were the enormous masses of snow remaining in the mountains at even so advanced a time of the season as July 27. It may, perhaps, be due to the steep, eastern faces, which, in many instances, are so placed as to allow the action of the sun's rays but a very limited influence. Looking down upon the accumulations of snow, and noticing the favorable orography of the region, I fully expected to find active glaciers within the Wind River Mountains.* Although none were discovered, traces were found of extinct glaciers, appearing so fresh

*NOTE.—Since the above was was written, the exploring parties of this survey have during the past summer found active glaciers in this range.—E.

that they should certainly be regarded as having existed at a very recent period.

Looking beyond the foot-hills we saw the low country stretching out in an unbroken expanse. Dark lines, produced by timber, indicated the courses of streams; and bluffs, that had given us some trouble in surmounting, disappeared totally. To the west and north we saw the Green River Mountain and the famous Teton Range, with its culminating point, Mount Hayden. Far in the distance, too, the Bighorn mountains rose in hazy form above the level of the plains, completing the northeastern horizon.

Having duly chronicled the date of our ascent on a piece of paper, and intrusted it to the protection of the monument, we commenced the descent. Upon reaching the snow-bank, which stretched for nearly a mile before us, we employed a method well known to school-boys for rapidly accomplishing our downward course. Sitting down upon the snow, which by this time had become a little softer than it was in the morning, we "slid" down the steep incline. Going at a very high speed, we had the satisfaction of accomplishing 500 feet of our descent within a very few minutes. This performance produced a high degree of pleasure in our dog, who evidently seemed to think that it was accomplished for his especial edification. Arriving at a convenient point we stopped ourselves and recrossed the snow-field. Our mules were somewhat rested by this time, and we started on the journey to camp. Avoiding the snow-fields which we had crossed in the morning we led them down a steep slope, and then returned by the same way we had come. About six o'clock in the evening we arrived at camp very hungry. As this was the highest peak we expected to climb during the summer, the successful accomplishment of our ascent gave us great satisfaction. Had we entered this portion of the range earlier in the season our work could have been completed only amid the greatest hardships.

Few mountain ranges, perhaps, present so typical an orographic structure, and from the summit of Snow Peak we had a particularly favorable opportunity of studying it. Its relative position, and the commanding view there obtained, render it one of the most conspicuous peaks of the range. No one before Wilson seems ever to have ascended it, and our party, therefore, was the second one that successfully made the attempt. Taking leave of our companion of a few hours, Mr. Fosher, we spent the evening in discussing the events of the day.

July 28 we continued our march northwestward, along the slope of the range, camping on a small stream. The day following we crossed the Big Sandy River, which, within the mountains, is a rushing stream carrying a good supply of water. Full of bowlders, and very swift, it is rather difficult to cross. We encamped that afternoon at the head of a swampy meadow, at considerable elevation. It is about 2 miles long and half a mile wide. Toward evening we saw a large grizzly bear (*Ursus horribilis*) in the grass, and proceeded to kill him. Being obliged to fire at very long range, because he took to flight, we missed him. Expecting to fall in with him again, we followed his tracks for a considerable distance, but darkness soon set in and we lost him. While endeavoring to retrace our steps toward camp, we encountered a second bear. Having shot at some other game, our stock of ammunition was so low that we did not fire. During the day we saw several porcupines. One of them was on a spruce-tree, about 16 feet from the ground. We had frequently observed that the bark was removed at varying heights from such trees, and we now found the porcupine engaged in this exercise. Before we could leave the dense forest, where progress was very much

impeded by fallen timber, it was absolutely dark. By ten o'clock the three bear-hunters gave up the idea of reaching camp that night, and, building several huge fires, "slept out." At that altitude the night was very cold, but by lying each between two fires we managed to keep warm. Next morning by eight o'clock we returned to camp, finding it readily as soon as daylight enabled us to distinguish our landmarks. After a hearty breakfast we set off on our journey. Riding for a short distance through a combination of swamps and "down timber," we soon emerged into a very fine forest. With ease we passed on through this until our progress was temporarily arrested by meeting with a band of elk. Shortly after we saw some deer, and "bear-tracks" were plentiful. Riding over smoothly-polished rocks and through shallow swamps, we finally reached the stream that lower down has received the name of the "Muddy." Where we camped on it that evening it by no means justified this appellation. Similar to the Big Sandy, it flowed swiftly, as a torrent, over large bowlders, often confined within narrow walls. No fish were found in it at this point, owing to rapids and cascades some distance down stream.

On the day following we marched up the Muddy. On the west side of this stream a long plateau-like ridge led up to Temple peak, upon which a station was made. Passing this peak, we found an Indian trail leading across the mountains. It is the one usually called the "Shoshone trail." We followed it to timber line and there camped. Two of the party rode on beyond the main divide, dnesceding some distance on the Wind River side. The trail was found to be a very good one, overcoming with ease the difficulties of the ascent. Much snow was still lying there, although the smaller banks were rapidly melting. From the divide a very beautiful view was obtained of the Wind River drainage to the east, and that of Green River to the west. East of the divide the trail leads over steep slopes composed of loose rocks. Winding in zigzag, it soon gains better ground, however. This trail leads from the base of the mountains, where it is made up by several others coming from farther west, directly across the range to Camp Brown. So far as I have seen the range, this is the most southerly feasible pass. Tracks upon it showed that two days before several Indians had passed over it, going eastward. They belonged to some of the hunting parties which had been absent from the agency at the time of our visit there.

On *August* 1 we turned back toward the plains. We had reached the northwestern corner of our district, and proposed marching eastward along the western base of the range. Following the trail down along the Muddy, our route lay over the high plateau-like ridge mentioned above. Leaving the trail there, we rode along the ridge and camped at its western end near some of the high foot-hills. Several stations were made, and on the next day we continued our journey downward. Riding "across country," we soon reached the trail and followed it. It carried us through a most interesting region as long as we remained at high altitudes. Everywhere were the most conspicuous proofs of glaciation. Shallow lakes were formed by the transverse placing of terminal moraines, and the rocks frequently showed a mirror-like polish. Before we reached the valley, we were agreeably surprised by meeting a large party of Shoshone Indians. Among them was our former acquaintance, from whom we had obtained some trout on the North Fork. Perhaps under no circumstances does the Indian appear to such great advantage as when on the march. The "warriors" are arrayed in their best garments, ride good horses, and are fully impressed with their own dignity. Seated high upon bundles of fur or other articles, the squaws present a specta-

cle less inviting, certainly, but no less picturesque. Swaying from side to side with the motion of the horse, carrying a child or two before them and one on the back, these creatures are the picture of unalterable helplessness. Haggard and worn, when old, they more closely resemble the type of a witch than anything else. Surprising to the stranger is the fearlessness with which small urchins and girls sit on their ponies. Gaudy colors and profuse ornamentation of both man and animal lend to the Indians a peculiar charm of appearance that clothes of civilized cut cannot replace. As compared to some other tribes, the Shoshones are careful of their dress, and produce a favorable impression. With our introductory "How!" and the same salute at parting, the main portion of the conversation with many of the individuals was concluded, and we proceeded on our march. After a long ride, during which we followed the trail down beyond the foot-hills, we reached the Muddy River, and that evening made our fiftieth camp of the season. The river was found to contain fine trout, and we enjoyed a change from venison to fish.

August 3 we marched southeastward along the base of the mountains. We there observed that a subsidiary chain separated from the main range, forming a series of isolated hills and groups. Cut by the drainage from the mountains, the continuity of this chain is repeatedly broken. From the relative elevation of the highest points, and the geognostic character, it is evident that a connection formerly existed. Making stations on the granitic hills to the left of our line of march, we reached the Big Sandy on August 4. Where we camped the old wagon-road, formerly known as the "Oregon trail," crosses the stream. Frémont travelled along this route, sometimes called Lander's Cut-off, on his way to the New Forks, from where he ascended the peak that bears his name. During the time of the Sweetwater mining excitement this road was much used by prospectors, who examined the lower portions of the range in the expectation of finding paying metalliferous deposits. Game is plentiful in the region of the Big Sandy, consisting of deer and antelope, and the stream contains an abundance of very fine trout.

Reports have been current for a long time concerning waterfalls on the Big Sandy above the crossing of the wagon-road. In order to satisfy ourselves upon this point we examined the river on August 5. The train proceeded along the road to the Little Sandy. Following up the valley, we found this soon growing narrower, until it changed into a steep cañon. Within this a growth of heavy timber lined the sides, and the water came tumbling and rolling down over immense bowlders, tree stumps, and fallen logs. In this way, owing to the steep fall of the river-bed, a series of very fine cascades is formed. No definitely developed fall was found, and, although we were disappointed, the wild character of the cañon and the beauty of the rushing stream amply rewarded us for our unsuccessful search.

Leaving the cañon, we made a station on one of the isolated granitic hills. At the base of this the wagon-road, which heretofore had remained southwest of the granite ridge, curved to the northwest and continued between the outer range and the western base of the main chain. The next stream eastward issuing from the mountains is the Little Sandy. Descending from the hill upon which we had made our station we turned southward, in order to camp on the Little Sandy, outside of the granitic ridge. To our surprise, we found an old buffalo bull quietly grazing near a grove of quaking asp. A lively chase and a few shots brought him down. He was evidently very old, and, having turned somewhat morose, left his herd to enjoy life in solitude. His meat was so tough

as to be unfit for eating purposes, and even his tongue required six hours' boiling without becoming palatable. During the afternoon we made a station on one of the small bluffs west of the stream. Antelope were very numerous, but shy.

On *August* 6 we regained the wagon-road and continued our march toward the Sweetwater. During the day we rode over the famous South Pass. As both Frémont and Dr. Hayden remark in their respective reports, it is a matter of some difficulty to determine accurately where the continental divide really is located. The ascent from either side is so gentle that it can scarcely be noticed. This pass certainly presents a more gentle slope than any other one crossing the "backbone of the continent." On the way we met large herds of cattle which were grazing in the valleys. Throughout the entire region there is good feed for cattle, and it is utilized by various cattle-owners. In some of the meadows hay is cut, which easily finds a market. After a ride of nearly 20 miles we once more reached the Sweetwater, where we encamped. Here the river was much larger than where we last had seen it, in the mountains. Attempts at isolated settlements had been made there a number of years ago, but with the decline of the mines they were abandoned.

Leaving the Sweetwater on the next morning we continued our march eastward, passing over some very pretty country. In the afternoon we camped at a small spring near some haymakers.

On *August* 8 we rode into Camp Stambaugh for the last time. While passing through South Pass and Atlantic cities I examined the mines there. As has been stated above, but few of them are worked at present. The owners and settlers generally are hopeful, however, and additional development of the agricultural resources of the region may give a new impulse to the mining interests.

Arriving at Stambaugh we found our old friends well, and a large quantity of mail awaiting us. While camp remained stationary there during the next day the examination of mines of the neighborhood was completed. Accompanied by Lieutenant Cole, the ride from place to place was rendered very agreeable. Before leaving the post we shipped our trophies of the chase and specimens, took a new stock of provisions, and, thanks to the courtesy of the quartermaster, had some of our mules reshod. Having completed all our arrangements, we looked forward to our final departure from the post that had become so pleasantly familiar to us. All the western portion of our district was finished and but seven weeks of the season remained to complete the rest.

CAMP STAMBAUGH TO ROCK INDEPENDENCE.

Bidding the officers of Camp Stambaugh a final adieu on the morning of August 10, we departed, carrying with us grateful recollections of their kindness and attention. Following the road which leads to Miner's Delight, we soon began to descend on to the Wind River drainage. Leaving the road near the beginning of the old sedimentary beds, we rode off to the southeast. A last view was here obtained of Red Cañon and its picturesque surroundings. Examining the strata as we passed over them, we gradually descended toward Twin Creek Cañon. Near its upper end we encamped at the base of a high, deeply corrugated sandstone rock. Upon its top we found the remnants of an old Indian "lookout." The view from that point commands several important passes, and it was, therefore, well chosen. Riding down the cañon, we reached Sheep Mountain on the day following. One feature strongly reminded us of the fact that we had descended considerably since leaving

Stambaugh—the occurrence of rattlesnakes. Meeting with several of them during the day, we had occasion to make some interesting observations. We found that when the snake is getting ready to strike it gradually raises the fore portion of its body from the ground, supporting it upon one or two coils near the tail. While this is going on the tail stands clear from the ground and the rattles are constantly in motion. Immediately before biting, the head, neck, and upper portion of the body, which may be raised to a height of more than a foot from the ground, are curved slightly backward, and then thrown forward swiftly with great violence. This is the "spring" of the rattlesnake which popular report has magnified very much. So far as we observed, the distance of the spring may amount to about two-thirds of the length of the snake. Of course this method of biting will be employed only under favorable circumstances.

From Sheep Mountain we had a very fine view of the surrounding country. Prominent in the landscape are the bright red colors exhibited by the Triassic beds. Whether disturbed from their original place of deposition or not, they readily yield to erosive influences, and then present bold escarpments, more or less ornamented by the effects of decomposition and disintegration. Having ascended Sheep Mountain on the west side, we commenced the descent on the east. Camp had been made in a narrow limestone cañon containing Beaver Creek. Perpendicular walls enclosed the small stream, which not far off loses its good, fresh water and turns extremely alkaline. Within these limestones a number of springs have their origin, flowing clear, cold water. A short distance from our camp, on the south side of the Beaver, we found a very interesting occurrence. This consisted in hot and cold sulphur springs. From a distance we had noticed a cave-like depression in the limestones. Upon examination this proved to be a vertical "drop" of the strata. The form of the present excavation is oval, about 200 feet long, 150 feet wide, and 120 feet deep. Lower down on the hill, toward the creek, we found the hot sulphur spring. A decided odor of sulphuretted hydrogen announced its existence. The spring bubbles up in a hole capable of accommodating two men. The temperature of the water is 96° F. About 250 yards off is a cold sulphur spring of similar constitution. No doubt there is some connection between these springs and the "drop," a point that will be more fully discussed in the geological report.

From all that we could learn before entering this section of country, it was the only one where we might apprehend any danger from Indians. Small parties of Sioux usually passed through it every summer, stealing horses and occasionally firing upon the settlers. Several times they had ventured within half a dozen miles of Miner's Delight, but at no time had their gain been adequate to the danger to which their predatory expeditions exposed them. During our entire trip through that region, however, we never saw an Indian.

On August 12 the train marched down Beaver Creek, while we examined the country lying toward the Sweetwater. That region is very much broken, well watered, and contains scattering patches of timber. Game seems to be very abundant. We saw a large band of mountain sheep and a great many antelope. As we were riding northward during the afternoon the appearance of a horse attracted our attention. Upon investigation we found that it was evidently a "stray," and in no connection with Indians.

A short distance east of Sheep Mountain the Beaver makes a sharp turn to the northward, retaining that course until it enters the Little Wind River. Along the stream we found a good Indian trail. Follow-

ing this we emerged from the region of hills into a typical "bluff country." With the appearance of bluffs, spruce, pine, and quaking asp ceased, and their places were supplied by piñon, cedar, and sage-brush. Riding northward on the trail, we took a look at the surrounding country. Before us lay an unbroken stretch of low, narrow bluffs, the nearest ones resembling "hog-backs," but the more distant ones showing horizontal stratification. South and east of us was the curving edge of a high plateau formed by the strata of the Sweetwater Group. Its sharply cut edges were clearly defined, and isolated points of considerable elevation rendered it more prominent still. Without any transition, the plateau was abruptly set off against the low country immediately adjoining it. Its steep slope was deeply furrowed by erosion, and groves of trees filled the narrow ravines. We were well satisfied to see this, as it promised us a sufficient supply of water and grass.

The trail on which we were riding kept along the creek very regularly, and after sundown we reached camp, which was made near it. Crossing the Beaver on the next day we rode in a southeasterly direction across the bluffs and ascended the steep face of the plateau. On our way we started a number of deer and antelopes from their cover and found a very fine spring. From the edge of the plateau, about 2,000 feet above the low country adjoining, we obtained a good view. To the north of us lay the Rattlesnake Mountains, and, farther on, the Bighorns. Southward the plateau sloped toward the Sweetwater in gently inclining terraces. Beyond the river we saw the Sweetwater Hills, which shut out all view of the lower country. East of us the sharp points of granitic hills north of the Sweetwater projected above the level of the plateau. A number of stations were made on the edge of the plateau, and in a heavy rain-shower we rode toward the Sweetwater, where our camp was located. Very good grass and water refreshed our animals after their several long rides.

August 14 we reached the Sweetwater and camped about 18 miles below Saint Mary's station. At this point all timber has disappeared from the river and nothing but sage-brush and willows remain. During the day we were obliged to ride in a broiling sun and at night the thermometer fell nearly to the freezing point. Here John, our cook, began to show symptoms of "mountain fever." Although he had been accustomed to this sort of life for more than ten years, this was his first attack of the distressing malady. On the next day camp remained stationary while we rode northward to make our first station on the granitic hills. After a ride of about 8 miles we reached the first one. Having completed our work there we separated, one party going to the edge of the plateau and the other to a high, round hill to the northwest. This latter was found to be composed of Carboniferous limestones. On its summit were seen a number of Indian "lookouts." Sometimes these are carefully built: a circular wall or one of horseshoe shape is erected, about 2 feet high, and behind this the sentinel lies concealed. Others are simply excavations, long and sufficiently deep to allow a man to remain hidden. In this instance, as in many others, the protection from observation consisted simply in piling up a number of bowlders, which, even in the case of an attack, would afford some shelter. Numerous chips of flint, chalcedony, and jasper, besides some broken arrow-heads, showed that the Indian stationed at this point had utilized his time by manufacturing his offensive weapons of chase and warfare.

August 16 we broke camp and continued our march down the river. About 5 miles below camp we found that the river flowed through a very pretty little cañon. A rent had been formed in some red, quartzitic sand-

stones, and the Sweetwater passed through it inclosed on either side by perpendicular walls 120 feet in height. Crossing the river we found the old emigrant road and the stumps of telegraph poles, which latter were destined never to be used. Small, dry alkali flats indicated the presence of lakes during certain seasons of the year. While riding along we saw a band of about forty elk. They started from the willow-brush on the river and soon disappeared in the adjoining granite hills. Recrossing the Sweetwater we rode over to some of the granitic hills. Very sparse timber, consisting of piñon and cedar, was scattered over them. Water appeared to be scarce, owing to the loose, permeable character of the rocks adjoining the granites. Antelope were plentiful, and tracks of deer and mountain sheep indicated their presence. On the way we saw several blue herons (*Ardia herodias*), a very graceful bird. They were stalking along a small swampy place, searching for food. About 4 miles below our camp of the 16th the wagon-road returned to the north side of the river, and fresh tracks thereon showed the proximity of white men.

Proceeding on our march down the river we reached the well-known Three Crossings and camped there. In early times this was a very important station, of which to-day nothing remains but the crumbling stone walls of an old house. The name was given to the place from the fact that the wagon-road crossed the river three times within a very short distance. Winding its serpentine course between the low, granitic hills, it closely hugs first one, then the other bank. Emerging from this narrow place we see before us a wide, meadow-like flat, covered with excellent grass. Bordered on the north side by the river and the granitic hills, the south side is protected by the bluffs of the Sweetwater Group. Sand, blown up into large dunes at favorable places, shows the force and persistency of the wind prevailing there. Much has been said about the agricultural prospects of this region. So far as we were able to judge during our trip, there is but little promise of their being realized. Within the time that we camped in that section of country the nights were exceedingly cold, and on the one we spent at the Three Crossings we had a sharp frost. It is possible, but not probable, that the summer season of 1877 was an exceptionally cold one. In this way we might account for the cold nights during August. Timber, for building, and other purposes, could be obtained from the neighboring hills, and stones are plentiful. A short distance from the river, irrigation would have to be employed in case agricultural pursuits were followed. Undoubtedly this region would prove to be a good grazing country, provided no raids from Indians were to be feared. Reports with regard to the safety of the place are so conflicting that but little can be decided on that point. At certain seasons some of the hostile Indians travel through that country for the purposes of hunting, and it is possible that an isolated settlement might be attacked.

For a number of miles, both above and below the Three Crossings, old graves testify to the former hostility of Indians. Situated upon little hills and bluffs the small stone mounds produce a compassionate feeling. Emigrants leaving more densely settled portions of the country to seek a happy future in the distant West were here laid to rest often without having even seen the "promised land." After the war had closed, the Eleventh Ohio Regiment of volunteers was sent into this country to keep the Indians in check, and their numerous graves show the cost at which the red-skins were to be subdued.

Opposite the Three Crossings is a low pass through the Sweetwater hills. From this point the latter present a very pretty scenic effect.

Timbered on their higher portions, they rise to a relative elevation of about 2,000 feet. Leading down toward the river are straight, regular ridges composed of the white rocks constituting the Sweetwater group.

Breaking camp on August 17, we crossed the river and traveled in a northwesterly direction. Soon after having reached the other bank we found ourselves in the vicinity of Agate Lakes. This name has been given to several alkaline ponds on account of the fine moss-agates there strewn all over the country. From the size of a pea to that of a good-sized apple the agates are scattered over the ground. They are water-worn and some of them show exceedingly pretty "moss." Slowly ascending the rising plateau we passed between a number of isolated granitic hills, until finally an uninterrupted stretch of gradually rising slopes presented itself. Finding no water on the plateau we were obliged to continue our course until we had reached its northern edge. Then descending the steep face, we encamped for the last time on Wind River drainage.

Owing to the heat of the day and the fatigue of riding, our cook had a relapse and was very sick for two days. Subsequently he became better, and after about a week had recovered. For two days we made stations along the edge of the plateau, looking down upon country that presented the typical aspect of "bad lands." Game was abundant; antelope, deer, and elk fell victims to our bullets, furnishing a good supply of provisions. One day we killed an antelope from the dinner-table, so little did our presence interfere with their movements.

On *August* 21 we retraced our steps toward the Sweetwater, and after a short march camped on a small stream at the base of one of the granitic hills. The next day we traveled in a southeasterly direction, and stopped within the main mass of granite hills. We were surprised to note their character upon closer inspection. Almost absolutely bare of vegetation, they presented steep smooth slopes. Often it was impossible to ascend them except by literally crawling, and even then the slippery surface made the climb difficult. The highest mountain or hill of the group has been named Hayden's Peak in former years. It is a dome-shaped mass of red granite, very symmetrical, with perfectly smooth sides. Crossing over a granitic ridge, where our mules proved themselves expert in the art of sliding, we again reached the Sweetwater Valley. Dry creek-beds, densely timbered with cottonwood (*Populus balsamifera*), quaking asp, and willow, promised water while seen from a distance, but we were obliged to ride to the river before we could obtain any. Camp was located directly opposite Whisky Gap, on the north side of the Sweetwater, from which place we obtained a good view of the Seminole hills. Crossing the river on the 24th of August, we again reached the wagon-road and followed it for some distance. On our way we passed Cloven Peak, so named because its highest point is split, causing a resemblance to the cloven hoof of a quadruped. Small fragments of granite formed below isolated hills on the south side of the river, but the main mass remained north of it. Passing a number of graves on our way, we found that they sheltered emigrants who had probably fallen victims to the arrows and bullets of Indians.

August 25 we rode southward to explore the ridges leading from the Seminole mountains to the river. Antelope were very numerous, having congregated in bands. Coyotes followed them in order to capture any that might fall sick or through other causes become an easy prey. Following up a small stream we came upon a meadow filled with antelope. Hay had been cut there and was stacked. The sight of antelopes quietly feeding around haystacks appeared to us as very incongruous. A

few wolves lying in wait, under cover of a ditch, were frightened by our approach, and the bullets we sent after them had the double effect of accelerating their flight and clearing the valley of game. Having examined the ridges in question, we returned toward the Sweetwater. Before us lay that narrow chasm in the granites which is known as the "Devil's Gate." A vertical opening appears in a small north to south ridge of red granite. Its width at the base is about 80 feet, and the height of the walls 400 feet. Through this fissure the river has found its way, rendering it impassable. Telegraph-poles, some wire, the ruins of a few old houses, and the wagon-road rounding the granitic point, speak of former enterprise in this region. For many years this "gap" has been a prominent landmark, and travelers associated it with the not far distant Rock Independence. In the earliest times of overland travel this latter received much attention. Its comparatively isolated position and its location at the beginning of a pleasant portion of the route have alike rendered it conspicuous. During the times of Indian troubles this immediate locality was considered very dangerous. We found our camp at the eastern base of Independence Rock. This monument of early days is about 90 feet high, situated directly north of the river near west longitude 107°. Its general form resembles the upper half of a round loaf of bread more than anything else, and the level accumulation of sand surrounding it renders it very prominent. For years it has been the custom of travelers to inscribe their names upon this rock, and we found more than one which has since become well known in connection with western exploration. The oldest date we found was 1844. Frémont's cross, which he cut into the rock, we did not see.

During the evening a herd of cattle, numbering 2,800, slowly approached along the wagon-road, sending a cloud of dust high up into the air. It was *en route* for Fort Laramie, and the drover had chosen this short, though perhaps more dangerous, trail. Fourteen men accompanied the herd, well mounted and fully armed. As we sat on the top of Rock Independence, near sunset, and watched the busy movements of the immense mass of cattle directly in front of us, the sight was a very fascinating one. Mounted on good "cow-horses" the herders proceeded to "round up" the stock, preparatory to camping for the night. After this process had been completed, it was astonishing to see upon how small an area so many animals could be crowded together. Camp remained stationary during the next day, while we made some explorations to the north and east. Sharply-cut bluffs extend northward to the edge of the plateau, from where a good view was obtained of the country beyond. We there saw the region which still belonged to the district assigned to us for the season's work. Lack of time forced us to abandon the examination of about 1,000 square miles. Rock Independence is located on the eastern border of our district, and when we left it we had but the southeastern portion to complete. On the Sweetwater, below the rock, we found the ruins of houses, one of which had evidently been an old stage-station, while the others probably sheltered members of the Eleventh Ohio Volunteers. Graves close by contained the bodies of some of the latter, and by their mute presence told a tale which is but too often repeated on our western border. An old bridge across the river and the remains of General Crook's recent camp were further evidence of the presence of the white man. Having concluded our work in that section of country, we proceeded to march to Rawlings Springs, on the Union Pacific Railroad, where we were to find our last month's provisions.

FROM ROCK INDEPENDENCE TO RAWLINGS SPRINGS.

Leaving the Sweetwater we commenced our journey southward on August 27. An old wagon-road leads through a pass in the granite hills, and from there along the tertiary ridges toward the Seminole Hills. Crossing, on this road, the Sweetwater Valley, we gradually ascended until we reached some isolated bluffs. From there the road falls, leading into a very pretty valley. Sandy Creek flows through this, furnishing an ample supply of water.

Sheltered on all sides by surrounding hills and bluffs this valley occupies a highly favored position. Several cabins have been built and a portion of the land is under cultivation. The settlers there state that the winters are very mild, and that the summer season is of sufficient duration to ripen grain. Very fine grass is found in the lower portions of the valley, and the cattle which we saw were in good condition. Antelopes are abundant and easily shot during the latter part of summer. We encamped upon the west bank of Sandy Creek. Wild currants, particularly the yellow species (*Ribes aureum*), grew in great abundance, and were just ripe at that season. The distance from this valley to Rawlings is about 50 miles, and the hay here gathered is taken to the railroad for sale.

Travelling up Sandy Creek we passed an old stamp-mill. A number of years ago some excitement was created by the reported discovery of rich mines in the Seminole Hills. This mill was erected, other improvements were made, and then the mines failed to sustain their unwarranted reputation. To-day no work whatever is carried on there. A short distance above the mill the creek forks. Our road followed the southern branch. Before long the ascent began to grow steeper, and we found that we were travelling in sand. Looking back upon the hills, the sand was found to reach up about 400 feet along their slopes. After crossing the pass we had several miles of sand-dunes before us. Travelling constantly toward the eastward, they permit vegetation to gain a hold at but very few places. In the depressions running east and west a number of shallow lakes were found, containing large flocks of wild geese and "black divers," (*Fulica americana*). Outside of the dunes, bordering upon them, were meadows containing small ponds. A large supply of hay is here obtained for the trade. This accumulation of sand is the eastern terminus of the long belt first observed at Mount Essex. Wherever there is a pass in the hills so situated as to afford free sweep to the wind, there we find the sand piled up in the greatest masses. In its general character this occurrence is analogous to that of the sand-dunes in San Luis Valley in Colorado. There the scale of horizontal distribution is by far smaller, however. Within the area covered by sand, water may be found south of Sandy Creek Pass, but beyond that it is very rare. We continued our march along the wagon-road for the distance of about 25 miles before finding any water. Then we reached a small alkali pond, enlivened by numerous sand-pipers (*Tringa sp.*). Evidently the water was low, a fact that was indicated by its extreme alkalinity and the large white margin surrounding it. Upon evaporation of the moisture contained in these shallow basins a portion of the alkalies are precipitated along their edges, forming a white efflorescence. During a bright day the brilliant white color of these deposits, which often cover very extensive areas, is exceedingly trying to the eyes. Wind carrying the fine alkali dust through the air fills eyes and nostrils with it, producing a disagreeable effect. Camping at the little pond we had discovered, we once more had recourse to sage-brush as material for fuel.

Following the road during the next day we found it to turn sharply toward a ridge running north and south. Near the base of the ridge, on either side of the road, were two alkali lakes. Passing through a narrow cañon, however, we found a spring—Brown's Spring—of good water, and a little stream issuing from it. Here we camped. To the eastward extended the broad depression through which we had passed, bordered by a high, regular ridge, composed of gray shales and sandstones. In the distance we could see the hills south of the railroad.

On *August* 30 we proceeded on our march to Rawlings Springs. Ascending the ridge at the base of which we had been camped, we followed along its crest for some distance and finally descended into a broad valley. Within a few miles of Rawlings we passed a "red paint" quarry. Local accumulations of red hematite, within certain formations, are quarried out or mined, and after being ground furnish a brown paint. Reaching the town during the forenoon, we encamped near Cherokee Springs, about four miles northward. An ample supply of mail was awaiting us, and we found our provisions in good order. Since June 20 we had been absent from all direct railroad communication. Rough-looking as well as sun-burnt, we presented a striking contrast to the men who wore white collars and clean cuffs.

FROM RAWLINGS SPRINGS TO WHISKEY GAP.

On *August* 31 we left Rawlings and marched westward along the railroad. No water being obtainable elsewhere, we camped at Separation Station, where our wants were kindly supplied by the agent. On the way we visited some of the coal-mines of that region, and saw a number of untouched outcrops. Stations were made on some of the prominent bluffs north of the railroad, where we were besieged by swarms of flying ants. Usually these animals do not bite, but in these instances they were not so generous. Crawling under the clothing they established themselves comfortably until removed by force. For two days more we remained on the line of the road. The country here is very barren, being covered with sage-brush and prickly pears. A few stunted cedars are scattered over the bluffs.

Our northward march toward the Sweetwater Hills was commenced on September 3. Leaving Creston Station early in the morning, we rode in a northwesterly direction. As we expected to find a very dry country, we had provided ourselves with several water-casks. During the following week these were of considerable service. It was our intention to make a march of about fifteen miles, and then find water if possible. Two of the party examined the country on either side of the route followed by the pack-train, but not even a moist place was found. Changing our direction slightly toward the west, we headed for some high bluffs. After having ascended these we found that we were near our trail of June 21. We were about twenty-two miles distant from Trail Lake, and as the mules showed decided signs of weariness we determined to make a dry camp by evening. Water contained in the casks was of good service to us, although the animals had to go without. Starting early the next morning, we rode northward, expecting to find some of the lakes mentioned by Frémont as existing in that region. While the train followed along a cañon cut into the sandstones and shales we kept on the ridges, in order to have a better view of the country. Several times we were disappointed in our hope of finding water by the deceptive effects of mirage. Upon our approach, the lakes we had seen from a distance were resolved into dry alkali-flats. About noon we saw water seven or eight miles dis-

tant, and changed our course toward it. When we had reached the place where we supposed the lake to be, having caught but a single glimpse of it, we again found a sterile white plain. A short ride, however, brought us upon a small rise of ground, and before us lay a large lake with innumerable ducks and geese. We had again reached the vicinity of the "sand-belt." Riding through sand and soil where the mules sank in to their knees at every step, we approached the edge of the water. A sudden sinking of our animals from under us, gave timely warning; we had reached a bed of quicksand. Retreating from that spot, we tried to get to the water at a number of places along the shore. Not only were our animals unable to get within twenty feet, but it was a disagreeable undertaking for men to reach the edge. Sinking into the sand, sometimes up to our knees, we finally succeeded in our efforts to obtain water. By filling our hats we attempted to take some of it to the mules, but the wear and tear of three months had somewhat injured these useful covers, and the water ran out as fast as it was dipped in. On the bluffs close by were a number of antelopes, gazing wistfully down at the water. From tracks they had made but a short time before we found that they too had approached the water's edge within twelve or fifteen feet at a number of places, but were forced to abandon the attempt of reaching it on account of the quicksands. Nothing remained for us but to do the same; we could not get our mules near enough to let them drink. Having remounted we proposed to try the other shore. While riding over to it we saw camp a short distance off, at another smaller lake. Although this one was not very accessible either, the animals obtained water from a small pond close by, after having been for thirty-six hours without it.

Immediately north of this lake we found a very interesting occurrence. A large number of mud-springs, several hundreds of them, occupied the slightly rising ground. Mounds shaped like beehives, from 2 to 15 feet in height, covered an area about a mile long and half a mile wide. At the tops of most of these mounds we observed circular openings filled with ice-cold water. This water held a large amount of mud in suspension, so that it attained the consistency of thin chocolate. It was not entirely safe to walk or ride over this ground, as many of the mud-springs were hidden by a superficial level layer of sandy mud. One of our party discovered this fact to the distress of his mule and himself. In the geological report a more complete discussion of the mud-springs will be found. Scattered in profusion over the ground were the bleaching bones of various animals. Buffalo, elk, deer, antelope, coyotes, and even smaller animals had fallen victims to the treacherous soil upon which they trod. We had no sufficiently reliable means of determining the depths of the cylindrical tubes containing the columns of mud-water, but from some trials we made we found them to extend downward for more than 10 feet in a number of instances. The temptation to obtain water in so dry a section of country must necessarily lead many animals to this region. Not knowing or appreciating the dangerous character of the soil upon which they step, many of them are engulfed, and their bones are eventually brought forth to the surface either by erosion or by the action of the water constituting the springs. Altogether the locality makes the impression of a huge grave-yard, in which the mounds are monuments erected to the innocent creatures that here have found an untimely end.

From the evidences we observed in the vicinity of these lakes we concluded that they must have been largely frequented by Indians in former times. Behind small hills of sand and at other sheltered places were innumerable chips of flint, chalcedony, and some obsidian, which were

produced in the process of manufacturing arrow and spear heads. Small tablets of sandstone, which must have been brought from a considerable distance, and pieces of buffalo or elk bone were used by them in their work. Many points were found, but mostly broken ones. While watching for the game, the hunters could here make the weapons wherewith to kill it. From the size of the majority of arrow-heads it may be inferred that they were used in shooting the various kinds of wild fowl which occur at these lakes. The proximity of the ambushes to the shores speaks for the same assumption. Having examined the mud-springs and their surroundings during the day on which camp remained stationary at the lake, we proceeded to resume our march toward the Sweetwater Hills.

On *September* 6 we started across the country, heading for the lowest depression in the range of hills before us. A long ride through sage-brush, over a sterile country, brought us to this pass. I am aware of no name that has been applied to it, therefore shall, provisionally, call it "Elkhorn Gap." Both from the west and from the east the long series of hills come to an abrupt termination. In the centre of the depression thus produced there stands an isolated bluff, having essentially the form of a truncated cone. Upon reaching the eastern base of the hills, after a monotonous march of nearly 30 miles, we found a small stream of water and encamped. Willow-brush and some scattering trees afforded us protection from the autumn winds that were now beginning to set in.

September 7, camp was moved down the creek about six miles, while we rode up on the hills west of the gap. Ascending along the crest of a winding ridge, we finally reached the summit. This was found to be covered with scattering timber, and was nearly flat. During the day we had constantly met with large bands of antelope, and here encountered both deer and elk. Having been hunted recently, these latter were shy and soon disappeared in the timber. From the summit we had a comprehensive view. We saw that the range of hills runs approximately parallel with the river, and is a very simple one in its structure. On the river side opposite, the granite hills presented a very characteristic appearance, showing their bare forms with but a trace of vegetation. For some distance westward, the Sweetwater Hills remain timbered, until they degenerate into mere bluffs. Pine and spruce on the top and quaking asp in the narrow gulches leading downward comprise the large mass of the trees. Some very picturesque little cañons are cut into these hills, and they abound in game.

At the immediate base of the hill which we were occupying we perceived several tents and a herd of horses. Riding down to investigate, we found encamped there a party of English gentlemen, who were on a hunting expedition. They had met with fair success thus far, and told us of a band of buffalo which was gradually approaching the hills from the north. Camp was moved about twenty miles westward on the day following, and we accompanied the English hunters in their search for the buffalo. We rode over the summit of the entire hill without finding them, after which our companions returned to their camp. We continued toward ours, and found two old buffalo bulls on the way, which were captured after a most exciting chase. It is surprising for how many bullets a buffalo can form the receptacle without dropping. Reaching camp near sundown, we found it located on a small alkaline stream, on the south side of the hills.

Having now arrived at a point from where our present work could be connected with that finished in the beginning of July, we crossed the Sweet-

water range on September 9, encamping on a very pretty little stream within Carboniferous limestones. During the day we rode westward along the summit of the ridge. From there we obtained our last good view up the Sweetwater Valley. While on the highest points, a stiff wind proved to be very troublesome to our work. The days were gradually getting colder, and the addition of these gales was not an acceptable one. Descending from the hills, we examined the bluffs and ridges leading northward, thus completing the most westerly portion of the work still remaining.

On *September* 10 we turned our mules' heads eastward. The geology of the region through which we were passing at the time required close attention, and the marches of the train were comparatively short. Riding along the northern base of the hills, on the day following we reached Elkhorn Gap and encamped there. Up to this time we had been favored with exceptionally good weather, but now it began to look threatening. About twelve o'clock at night a severe rain-storm set in, lasting only a few hours, but moistening us most uncomfortably. On the morning of the 12th we continued our march eastward, still remaining on the north side of the hills. We made a number of stations on sedimentary hills until a violent rain-storm, followed by hail, forced us to abandon the high points. While seeking shelter from the hail, we found a cave in some limestone strata and utilized it to good advantage. Nevertheless we were wet and cold. Despairing of being able to wait sufficiently long until the steady rain which was then falling should have ceased, we rode on looking for the trail of the pack-train. Although it was nearly obliterated by the heavy shower, we succeeded in finding it. Trusting more to our mules' unerring instinct than to our own judgment, we dropped the reins and allowed them to proceed. Travelling along the slope of the range, we crossed a number of small streams well timbered with cottonwood. On one of them glacial moraines extended down far into the valley. In this vicinity the hills were far more rugged than we had found them elsewhere. Stratigraphical disturbances were denoted by the character of the region. As we were slowly making our way up a steep, slippery hill along an old game-trail, heavy banks of fog were rolling up from the valleys and cañons below. Although these fogs are generally not of very long duration, we were anxious to obtain a view of the country beyond the ridge before descending. Urging our mules on we lost the trail, and arrived on top only to find everything an absolute light-gray blank. It was impossible to distinguish even a horseman for a greater distance than fifteen feet. While waiting for a partial clearing before proceeding any farther, a sudden momentary break in the impenetrable fog-bank before us revealed camp within two hundred yards. Directly the gap closed again, but it required only a few minutes for us to reach our tents. One of the most beautiful sights that can be found in the mountains is the rapid rising of dense white clouds in cañons. Rolling up the slope of the valley, creeping along the walls, and finally emerging from their confinement, the elastic masses gradually approach the observer, until all of the earth is shut out from his sight excepting the little spot upon which he stands.

It was necessary to return to some points during the next day which the storm had prevented us from visiting. Ascending the ridge from camp, we found the sources of the glaciers high up in the hills. Crossing one ridge after the other, while riding alternately through very fine timber or meadows, we finally turned southward and reached the summit of the hills. On the way, we heard elk "squealing" in various directions. Obtaining a good view into the low country southward, we rode

along the crest of the ridge, "jumping" elk, deer, and antelope every few minutes. The entire hill appeared to be alive with game. In the distance we saw a large green tract covered with a great number of dark spots. With the aid our field-glasses, we found these latter to be elk. Having ridden on for about 5 miles in the timber, we found ourselves literally surrounded by these animals. On every side they crashed through the bushes, presenting a noble sight. As we emerged from the forest, near the western end of the hills, we saw a large band of them slowly filing across it. Our mules had become very nervous by this time, the presence of so many animals seeming to disturb them greatly. We watched the solemn procession, without being seen, from behind some bushes. Just as we turned to leave, another band came up, following in the trail of the first. This one was larger. Bucks, cows, and calves all marched in a long line, the first-named uttering their melodious but piercing "squeal." With the heads thrown forward, the horns far back, and the perfect wilderness of prongs, where half a dozen or more animals were near together they presented a sight never to be forgotten. As we wanted some meat, we shot a young cow. She dropped, but was evidently not hurt very much, as several bucks urged her to get up, by using their horns, and she complied with their wishes. One old elk was the object of our ambition; his height reached about a foot above any of the others, and his horns, thrown back, extended nearly to his tail. Irregular prongs produced an effect resembling the horns of a moose. A shot in the neck dropped him, but he recovered before we could reach him, and disappeared in the timber. As the afternoon was advancing, we could only make a short search, and reluctantly abandoned the place, leaving him to his fate. A moderate estimate of the number of elk in the second band would place it at over four hundred.

Descending from the summit of the ridge, we returned to the camp which we had left in the morning, and from there followed the trail of the pack-train. Taking advantage of short game-trails we passed over the ground rapidly. A number of streams, which contain water at this elevation, were crossed, and were recognized as the continuations of dry "washes" in the valleys northward. Quaking asp, cottonwood, willows, and some pine were found on them. Toward evening we reached a very pretty little valley where we found a log cabin, and some men engaged in hay-making. They had seen our pack-train during the morning, and by pointing out to us the place where it had crossed the west ridge, enabled us to make a short "cut-off." Before long it grew dark, but the mules kept the trail. After having ascended a high ridge, trusting entirely to our animals, as we could not see enough to guide them, we discerned a light of apparently the size of a candle. Keeping the direction, which we fixed by the position of a few stars, we rode on for several hours longer, and finally, at eleven o'clock in the evening, reached our camp, on the east side of Whisky Gap, after a day's ride of 45 miles.

During the following day camp remained stationary in this famous pass. In the morning the wind was so violent that it seemed doubtful whether we could make any successful stations. While one party ascended the hill to the east of the gap, we rode on that to the west. Whisky Gap forms the boundary between the Sweetwater Hills and those farther east the Seminole Range. Geologically and structurally the two belong to one system, but the mind of the early settler has seen fit to separate them. About 12 miles west of the gap the wagon-road, following along Sweetwater River, forks, and the one branch leads through the pass, on the east side of Muddy Creek. From the gap it runs in a southerly direction, passing Bell's Springs, and eventually reaches

Rawlings Springs. This road is considered a better one than that through Sandy Creek Pass, as it avoids much of the heavy soil which must there be traversed. On the east side of the gap the Seminole Mountains present a very rugged and torn appearance. Bare rocks, standing perpendicular, project beyond the timber, and render travel there very difficult. They owe their position and prominence to violent stratigraphical disturbances. On account of the wind, which was blowing a perfect gale, it was almost impossible to ride along the summit of the ridge, and we were obliged to seek shelter in the forest. After obtaining the information we had sought, we returned to camp in the evening.

FROM WHISKY GAP TO RAWLINGS AND FORT STEELE.

September 15 we left Whisky Gap. The wind was blowing more furiously than even the day before. Riding northward, we ascended a narrow ridge, but were unable to maintain our footing and had to go down on the other side. Selecting another which appeared to lie a little out of the direct course of the wind we reached its summit without much difficulty. Descending a little to leeward, we rode in shelter towards its highest point. Having dismounted we found it impossible to stand there, and were obliged to take our notes lying down flat. The Seminole Hills present a very pretty appearance from this side, if seen from an elevated point. Successive strata of varying color show nearly vertical faces, arranged like terraces, one above the other. White, light yellow, and reddish colors predominate, and are set off to advantage by the dark green of the timber. Game appears to be abundant here, although the country is more difficult to travel over than the hills farther west. We were anxious to find a locality where Dr. Hayden in 1870 had collected a number of highly interesting fossils. For the purpose of finding this place we descended from the ridge and reached the wagon-road leading westward to the Sweetwater. A sharp ride against the strong head wind brought us rapidly nearer the river. Searching for bluffs which might answer the description given, we finally found the place, not far from Cloven Peak. Regaining the wagon-road we hurried back toward camp. Where the road makes a turn to enter the gap we found a party of English sportsmen encamped. Here we heard, for the first time, the news that one of our exploring parties had been obliged to leave the field earlier than they had intended on account of the troubles with Chief Joseph. They had, but a short time before, passed through Whisky Gap on their way to Rawlings Springs. Our camp was to be located on one of the small streams flowing northward from the Seminole Mountains, and we accordingly headed our mules eastward. Crossing ridges and narrow gulches, both trending north and south, we met with large quantities of game, mostly antelope. At this season of the year they congregate in bands of considerable numbers, and are less shy than earlier in the summer. A thin wreath of smoke curling up out of a narrow valley to the right of us revealed the presence of camp, and just as the sun sank below the horizon we reached it, tired from our ride of 46 miles in a heavy wind-storm. It was decided that Clymer and I should leave the party on the 17th and proceed to Rawlings, from there to go farther west by rail, while the main portion of our small *personnel* would remain in the field a few days longer.

On the day following we marched eastward along the northern slope of the Seminole Mountains, continuing in the course of the day before. We passed a number of small streams containing beaver-dams of considerable size. Near the mountains these animals appear to occur in large

numbers. Their characteristic "cuttings" were fresh, and from the number of small trees that had been cut down, we judged that a large number of beavers must have been at work. To one who has never seen the amount of work that can be accomplished by these industrious animals, their efficiency must seem almost incredible. Trees more than a foot in thickness are felled by them, are cut into lengths, and utilized for the purposes for which they intend them. Willows and quaking asp often appear as if they had been mowed down, so evenly are they cut. The material obtained from these two the beaver stows away as provisions for the winter. Frequently, pieces that they have cut into lengths to suit themselves can be seen floating down stream, until they either become water-logged and sink, or are caught by a dam. The construction and form of these dams is such as to resist most effectually the currents which may threaten to destroy them, and they are thoroughly well adapted to the character of the banks between which they extend.

During the continuation of our march we passed the abandoned mines which have been mentioned in previous pages. So far as we could determine, but little work had been done on them, and our observations confirmed the reports with regard thereto. It is stated that rich ore was found at first, but upon further prosecution of the mining operations, it was soon demonstrated that this had been contained in a small "pocket" only, and that a continuation of the enterprise would not be remunerative. In the course of the afternoon we reached the old stamp-mill, and encamped on Sandy Creek, a short distance above it. Our baggage and specimens were separated from such articles as we desired to carry with us on the following day, and packed up. We had a long ride before us, considering that our mules had been in constant use for three and a half months, and were glad that we could give them good grass and water for several hours before night-fall. Letters were written, to be mailed at Rawlings, and two of the party, for the last time during the season of 1877, rolled themselves in their blankets under the protection of a brightly-starlit sky.

On *September* 17 we rode from Sandy Creek Pass to Rawlings Springs, where we arrived during the afternoon. We followed the same route that we had taken on August 29 and 30. Passing one of the small lakes near the sand dunes, we came upon a band of elk, and made our last shots of the season. Lloyd had accompanied us to return to camp with the mail. During the day the pack-train moved westward, along the western base of the Seminole Hills, and camped on Muddy Creek. Leaving with the night train, I proceeded to Evanston, Wyo. On the 18th Lloyd returned to camp, and the party slowly completed its march to Rawlings and from there to Fort Steele. Having finished the summer's work, its members started for Cheyenne September 23, and left the day after for the East.

At Evanston I had occasion to examine the coal-mines of that place and vicinity. Coal is extensively mined there, and as its quality is good, this industry is in a comparatively flourishing condition. On the 26th Wilson reached Evanston, and on the day following we made the last station of the primary triangulation together on Medicine Butte. Having completed my work, on the 29th I left for Cheyenne, and October 1 started eastward.

We had, during the summer, finished the survey of nearly the entire district that had been assigned to us, 11,300 square miles, and had all escaped without any apparent injury. Our arrangements as to the reception of provisions and mail had been successful, and we were enabled to keep our mules in good travelling condition, due, in a great measure,

to the courtesies extended to us at the posts. Much of the country over which we had passed is exceedingly sterile and difficult to survey with any sort of comfort, but again we found regions more delightful than which there are probably few in existence within the Rocky Mountains. All danger from Indians, of which there was some prospect at the outset, had been escaped, and with the exception of the attacks of mountain fever we had been troubled with no serious sickness. Returning to the East, Mr. Chittenden had the misfortune to be taken sick, and has been confined to his bed for nearly the entire winter. Upon his recovery, which now seems assured, he will prepare maps of the regions we have travelled over, and with them as a guide the subjoined geological report will become more intelligible than it can be at present.

CHAPTER I.

INTRODUCTION.

Even before the discovery of gold in California attracted large masses of emigrants to the Pacific coast, the highly colored reports coming from that region made felt the necessity of an overland route. At the time when Frémont made his first expedition to the Wind Rivers, in 1842, all the country lying beyond the Missouri was almost absolutely a *terra incognita.* Venturesome men, often with their families, had a number of years previous to that time gradually pushed westward, and a route had been established by which to reach the land of promise. Taking advantage of both northern and southern passes across the continent's "backbone," and utilizing the shrewd ingenuity with which Indians had engineered their trails, two roads soon became tolerably well known. Of these, the southern one, "Cherokee trail," approximately follows the forty-first parallel, while the northern one, called the "Oregon trail," follows up the Sweetwater and crosses the continental divide by way of South Pass. Both of these roads were used extensively before the transcontinental railroad monopolized the larger portion of the carriage.

It was the object of Frémont's expeditions, carried out from 1842 to 1844, to make a survey which would connect the Pacific coast with the Missouri River. His energy and perseverance enabled him to bring this undertaking to a successful conclusion. From Fort Laramie he travelled by the Oregon trail, and to his descriptions we owe the first reliable knowledge with reference to that region which was assigned to us for exploration during 1877. Since the time when Frémont passed along the emigrant road up the Sweetwater River, that section of country has been the object of much further exploration. During the prosecution of the Pacific Railroad surveys it was reached, and some portions of it examined. In 1870, while exploring a large portion of Wyoming Territory, Dr. Hayden travelled over the same ground. Later—in 1873—the expedition in command of Captain Jones again covered some of the same ground. Upon maps, prepared for the uses of the War Department and the General Land Office, we find recorded such information as had been derived from the older reports and from a number of smaller military *reconnaissances.* During our work in that country the survey was made continuous, and while heretofore the information furnished has been fragmentary, it is now, topographically, complete.

Indians, since the earliest times, had been more or less troublesome, and until the latest subjugation of the Sioux, travel in some portions of that region was generally considered as attended with some personal risk. The northwestern portion of our district and the Medicine Bow Mountains, not far distant, are well known as favorable for the hunter. Annually several bands of Indians, belonging to different nations, were in the habit of visiting them for the purpose of obtaining meat and skins. This practice has been regularly kept up until within a few years, but now their appearance at these places cannot be relied upon.

Within the district we found varied features of great interest. Mountains of grand structure, plains equally typical, and localities well adapted

to the uses of white men were contained within its limits. Lakes, rivers, and streams were seen there, the latter two only for portions of their courses, with the exception of the Sweetwater, which was surveyed throughout very nearly its entire course. Few incidents, perhaps, are so gratifying to the explorer as to follow a river from its first sources down to its mouth. While the little brook first met with can be crossed by a single step, the volume of water is gradually swelled until, finally, it may become a question whether the stream can be forded or must be crossed by swimming. The observations of the widening valley, the increasing effect exercised by a growing stream, and the acquaintance with the entire system of drainage, furnish a peculiar satisfaction to any any one making them.

In the subjoined pages we shall first consider the surface character of the district examined, and then its geological structure. Form and size of the various elevations and depressions, the distribution of water, either flowing or in still bodies, stand in such close relationship with the geognostic and stratigraphical conditions of every region, that a knowledge of one is requisite in order to fully appreciate and understand the other. With a view to accomplishing this end to best advantage, a special discussion of the topographical features is inserted, which can subsequently be referred to during the description of the geognostic and geological character of any locality under consideration. Without the aid of a map, prepared upon a sufficiently large scale, the only available data are notes and memory. For this reason, much of the detail features observed must necessarily be omitted, and any discussion of topographical structure must be confined within narrow limits.

TOPOGRAPHY.

Glancing at a map of Wyoming, we will usually find a large blank left in its southern central portion. This represents the southern part of our district, lying between west longitude 107 and 109 degrees, and on either side of the forty-second parallel. In its topographical structure this region may be regarded as very uniform. Bluff succeeds bluff in regular arrangement, retaining about the same relative level. Valleys varying in width have been cut into the yielding material which composes them. Only in comparatively rare instances do we find any point reaching a considerably higher elevation than that of its surrounding. In case we do, its existence is generally due to the influence of volcanic rocks. A number of buttes formed in this manner, rising above the level of the surrounding bluffs, are found along a line extending in a northwesterly direction from Red Desert station. Their prominence is due to the presence of ejected lavas. In the central region of this uniformly depressed area we find broad valleys, sometimes containing lakes. Along a certain line, trending a little north of east, there are modifications of the usual forms which are produced by the accumulation of sand. By lying up against the sides of the bluffs, or by forming wave-shaped low hills, the presence of this sand changes the detail-character of the regions within which it is found. If a general type should be given, indicating the form and distribution of the bluffs within this section of country, it might be described as long, narrow ridges, cut transversely by fluviatile erosion. That erosion has shaped the entire surface of this region, there can be no doubt, excepting the isolated places where eruptive activity has stamped its impression. We must regard this portion of the Territory as, primarily, a long, even slope to the south, beginning at the southern base of the metamorphic elevated area. Erosion

has removed enormous quantities of the rocks, and has left the surface in the shape we now find it. Near the northern border of the region under discussion we find remnants of large accumulations of sedimentary strata which have disappeared. Such remnants are expressed in the form of prominent, isolated bluffs, and in a thickening of the strata. In a certain sense, the gradual rise northward may be regarded as forming a transition from the low country to the Sweetwater Hills. Geologically the two are in intimate connection, but their orographic relations are not so evident.

SWEETWATER HILLS.

On many of the maps representing Wyoming this small range is designated as the "Sweetwater Mountains." Dr. Hayden has pointed out in his report of 1870 that the appellation of "hills" was preferable. A short distance south of Pacific Springs there are a few isolated bluffs—table buttes—which may be regarded as the western terminus of the Sweetwater Range. From there eastward the hills present a uniform appearance. Continuing without many breaks, they extend as far as Saint Mary's. At that point the range is somewhat disrupted, owing to a change in the geognostic structure. Steep granite hills, covered in part by sedimentary strata of Carboniferous age are there found south of the river. Valleys of erosion have cut in deeply, and narrow cañons indicate the changes of composition. From there eastward the range of hills remains essentially unbroken, and continues to Elkhorn Gap. Although the range retains a nearly even elevation of about 7,500 feet; it appears as a series of hills when seen from the valley north of it. Creeks and streams have cut down deeply into the range, forming convenient low passes. At Elkhorn Gap we find a wide depression, breaking the connection of the hills. Near the western end of the gap there is a prominent butte, comparatively isolated from the range. Seen from a distance, where its base disappears, this butte shows itself as a hive-shaped projection. East of the gap the range continues again unbroken until it falls off steeply at Whiskey Gap. On the north side the hills are regularly carved by erosion, while to the southward they present a more even slope. Between Elkhorn and Whiskey Gaps the range is very regular again. According to the nomenclature as applied to this region the continuation of the hills eastward of Whiskey Gap is regarded as a separate group. It has received the name of "*Seminole Hills.*" Topographically and structurally, there is no reason why this distinction should be made. The two groups belong to the same system in every respect. They have undergone the same dynamical changes, are undoubtedly of the same age so far as elevation is concerned, and the only means of separating them exists in the formation of the depression which breaks the continuity. The relations of both groups to adjoining localities are the same and they are of equal importance orographically. A short distance east of Sand Creek Pass our district ends, and the continuation of the hills passes beyond it. While the southern slope of this range is comparatively steeper than the northern one along the eastern half, the two are nearly alike farther west. Starting from an elevation of about 6,500 feet, a long-continued series of ridges slope gently down towards the Sweetwater River. In some instances, particularly near the western end of the range, the angle of slope becomes steep, owing to the fact that the river encroaches upon the hills. Near the little cañon of the Sweetwater, about west longitude 108° 20′, the long flat-topped ridges begin. They are separated from each other mostly by narrow dry gulches. In case they contain water, they are usually wider and have flat meadows along the streams.

From various points along the crest of the range the regular arrangement of these ridges can be seen. Extending northward for distances varying from 3 to 12 miles, they usually present an unbroken slope. If it is broken, they are terraced. At varying distances from the river these ridges terminate more or less abruptly and the valley proper begins. This is level, and changes in width in accordance with the strata or rocks adjoining either side.

The Sweetwater Hills and their eastern extension, the Seminole Group, have a trend of nearly east and west, forming the last range from the Sweetwater southward to the Union Pacific Railroad. On the first-named the highest point reaches an elevation of 9,200 feet above sea-level, on the latter an altitude of 9,900 feet.

Inasmuch as two names have been given to the same range, and have been repeatedly published on maps and in reports, they will be retained in the subjoined report. It will there be seen that no structural difference justifies the separation, as, too, it is certainly not warranted by orographic or topographical features.

SWEETWATER PLATEAU.

Looking from Sheep Mountain towards the south and southeast, we observe a long line, almost unbroken, of steep white cliffs, resembling somewhat the southern face of the Book-Cliffs of Colorado. The edge of these cliffs does not run in a straight line, but shows numerous deep indentations and projecting sharp points. The general trend is a little north of east. Towards the north the slopes presented are very steep, sometimes precipitous. Erosion has cut narrow gulches, timbered with quakin gasp and spruce into the soft strata. Without many horizontal breaks, these faces sweep down in a straight or slightly curved line to the lower country, northward. If we ascend the sharply-defined edge, we find that it maintains an almost uniform absolute elevation, averaging about 6,500 feet. To the southward we will see a gradual gentle slope toward Sweetwater River. Retaining this character throughout its entire extent, I regard the designation "Sweetwater Plateau" an appropriate one for this region. The distance of its edge from the river varies somewhat, dependent upon curves made by either. At some points along the plateau-rim, we will find hills projecting above the usual level. In this case the difference of relative elevation is either slight, or the hills are formed by some older geological formation than that exhibited on the faces of the cliffs. Descending along one of the north to south ridges, we find that they are cut off sharply upon reaching the valley of the Sweetwater. This plateau, as well as the ridges leading from the Sweetwater Hills to the river, owe their formation to a tertiary deposit of considerable thickness. Speaking from the standpoint of a geologist only, the two together might aptly be designated as a "basin," but the configuration of the surface is such as to render this term inapplicable. In one sense of the word a "basin" is formed by the gradual slopes towards the river, which are exhibited by both sides. Their relations, however, firstly to the Sweetwater Hills, and secondly to the low country northward, forbid their classification as such. The area occupied by this plateau extends from a point nearly due south of Sheep Mountain eastward to the terminus of our district. On some maps the plateau-edge may be found indicated by notched lines connecting the region of Stambaugh, through isolated hills, with the western end of the Rattlesnake Mountains.

GRANITE HILLS.

A decided break occurs in the even slope of the plateau by the unexpected protrusion of a series of more or less isolated granitic ridges or hills. About 18 miles above the Three Crossings, on the Sweetwater, the first of these hills are noticed. Heavy masses of isolated red granite rise considerably above the surrounding tertiary deposits. As we travel from that point eastward, the hills make their appearance at shorter intervals, and are eventually connected so as to form more or less extensive ridges. A short distance below the Three Crossings they assume the type of a compact groupe. Connected with each other, to the exclusion of the tertiary sediment, the hills here present a very striking appearance. They are almost entirely destitute of vegetation, and show peculiarly rounded, smooth surfaces. Nearly the whole mass of these hills remains north of the Sweetwater, and only small, isolated fragments of the granite make their appearance south of the river until we reach the Devil's Gate. Hayden's Peak is the most prominent one of the group. Cloven Peak is another sharply-defined hill in the group. On several maps the inscription "Granite Hills" or "Granite Ridges" may be found. It is to be presumed that these names were put on rather to convey some definite information than to represent the appellation given to the group. The first name, however, is a descriptive one, and I have adopted it for these granitic exposures. As we proceed still farther to the east, we find the "Devil's Gate" within the area occupied by the hills. Near the one hundred and seventh meridian, Rock Independence, a most famous landmark, is located. This is merely a huge block of granite, isolated from the main portion of the hills by intervening areas of sand. Northward of the Granite Hills the edge of the Sweetwater Plateau continues eastward, and this, as well as the hills, extends beyond the limits of our district.

At the point where granitic buttes first make their appearance they are about 8 miles north of the river. Trending in a southeasterly direction, they reach it about 12 miles above the Three Crossings. Although the Sweetwater usually winds its way around them, it cuts through narrow ridges at a number of places. Most prominent among these is its passage through the Devil's Gate. While the group of hills has, up to that point, maintained a course nearly due east and west, it here takes a sudden bend to the southeastward, the river cuts through it, and flows onward north of the hills. So far as we could determine from a distance, the Granite Hills eventually connect with the eastern extension of the Seminole Mountains. Seen from long distances, this group presents a very rugged appearance. No timber exists on the hills to modify their outlines, and the impression obtained is that of a high range. Rising abruptly from a very gentle, regular slope, they closely resemble rocky islands projecting above the level of the sea. Even in their present form do they thus afford a reminiscence of the conditions existing at that locality ages ago.

WIND RIVER RANGE.

Within our district is included a portion of the Wind River Range. All that part lying south of north latitude 43° fell to our share. That section of the Rocky Mountain system which has received the name of the Wind Rivers forms the continental divide for a considerable distance within our district. So far as explored by us, the range is a very typical one, regular in its structure and in the distribution of its several members. It may appropriately be divided into three chains—the main or western, the chain of foot-hills, and the chain of outlying hills. Of these

the first contains the high peaks of the range, culminating in Frémont's Peak, 13,570 (*Frémont*) feet high. Although this is beyond the limits of our district, we were enabled to recognize its position from the summit of Snow Peak. On the western side the main chain is accessible by way of the ridges extending into the low country. They lead to lower elevations without having formed any secondary chain. To the east the main chain falls off very steeply, not unfrequently presenting perpendicular or overhanging walls. From that side the highest peaks of the range may be considered inaccessible. Following in a southeasterly direction we find a number of high mountains occupying the crest of the western chain. As is usually the case in the Rocky Mountains, the highest points show about the same altitude, and only a few are found to exceed by several hundreds of feet the average elevation. Snow Peak is an exception of this kind. Located in the main chain, it rises to an elevation of 13,400 feet above sea-level, about 500 feet higher than the general altitude of the neighboring summits. From there toward the southern end of the range no more prominently high peaks appear, unless we except Stambaugh Peak. Located near the southern terminus of the Wind River Mountains, this peak shows an elevation of 12,700 feet. The main chain gradually diminishes in height as it approaches the low country, and Stambaugh Peak, therefore, appears higher than it really is. On various maps the name "Frémont's Peak" is placed opposite a number of different mountains. It may be found so as to indicate Stambaugh, or, more frequently, Snow Peaks, and may be seen where no prominent peaks occur in fact. Both of the mountains above named were ascended by our party, and no evidence of Frémont having been there was observed. Besides this, his descriptions do not tally with those localities. From Stambaugh Peak the range rapidly falls off, the main chain disappears in the foot-hills, and these gradually merge into the lower bluff-country.

As the chain of foot-hills we may regard a succession of hills, parallel to the main chain, on its eastern side. The steep slopes of the latter form a somewhat broken, abrupt depression between the two. Ridges ascending from the western base of the outlying hills lead up to the summits of this second chain. The highest points are comparatively isolated, being separated from each other by saddles sometimes a thousand feet in depth. They were found to reach above timber-line (11,000 feet above sea-level) in many instances, and presented bare, sharp points. Southeast of Stambaugh Peak, the difference between these two first chains is obliterated. A more or less steeply sloping series of hills leads down to the lower metamorphic area within which the mining settlements are located.

The outlying chain may be characterized as one parallel to the two just described lying to the eastward of them. It is composed of sedimentary material, and is analogous to the "hog-backs" of Colorado. Presenting comparatively easy slopes toward the east, the descent on the western side is steep. Deep, narrow valleys are formed between the base of the foot-hill chain and the western edge of this one. Running, necessarily, parallel with and between the two chains, the foothills are cut transversely by the streams issuing from the mountains. In a like manner is the outlying chain subjected to breaks of its continuity. At some localities the gaps permitting the passage of streams are comparatively wide; at others they are merely cañons with vertical walls. Extending along the eastern base of the foot-hills, this chain follows the range southeastward to the vicinity of Miner's Delight.

Passing on, outside of the metamorphic area, it forms the little cañon of the Sweetwater. On the south side of the river it gives rise to the small carboniferous hills that have been mentioned in connection with the Sweetwater Hills. At that point there can no longer be any distinction made between the regular chain and the Sweetwater Range. The two merge into each other imperceptibly. In the vicinity of Stambaugh and at Atlantic City the foot-hills have been greatly modified, changing into low, rolling hills toward the south and southeast.

Near the northwestern corner of our district, at the exit of Muddy Creek from the mountains, a small, subsidiary range separates itself from the western base of the main chain. Diverging with increasing distance we find a comparatively level valley of triangular shape included between the two ranges. That designated as subsidiary is composed of isolated groups or hills composed of red granite. They are arranged in an approximately straight line, and evidently formed a continuous chain at one time. Northward they form an integral portion of the main chain, being absorbed, as it were, within its western slope. Toward the south they gradually diminish in height, until the hills disappear within the rolling metamorphic area. Streams coming from the mountains have cut their way through this little chain, completing the isolation of the individual hills or small groups, and affording low, convenient passes.

The trend of the Wind River Mountains is very nearly south 45° east. Parallel among themselves are the three chains above discussed, until they join together in the metamorphic area on the Sweetwater River. At the distance of about 28 miles, which we may regard as the length of the western subsidiary range, its divergence from the main chain produces a valley about 4 miles in width. Topographically considered, this short, low chain can be considered as a terminal spur. Taking into account, however, its geological structure, it will be more correct to regard it as a subsidiary range. The total length of the Wind River Mountains is so short that the term "spur" would, perhaps, not be properly applied to a series of hills so extensive as the one under consideration.

BLUFF-REGION OF WIND RIVER DRAINAGE.

Beyond that chain of the Wind River Mountains which has been designated as "outlying hills" the bluffs begin. In the vicinity of Sheep Mountain a succession of stratigraphical disturbances have resulted in producing a "broken" appearance of the country. This extends over a small area only. North and east of that hill the surface of the country resolves itself into a series of parallel bluffs. In their general direction they at first exhibit a parallelism with the Wind River Range. As we recede from the mountains, however, the trend and form of the bluffs is determined directly by the character and position of the strata composing them. At some localities the character of the country typically represents "*terres mauvaises.*" Rising abruptly from these low bluff-regions we observe the steep edge of the Sweetwater plateau. The lowest elevation which we reached in this section of country was on Beaver Creek.

Along the eastern base of the outlying hills, toward Camp Brown, northward, the bluffs are located nearer the range. They are very regular in their course and form, and, gradually diminishing in height, they extend for miles along the Wind River Valley.

Although we had within our district a large proportion of low, flat country, we had a sufficient diversity in its mountainous portions.

DRAINAGE.

Sweetwater drainage.

The Sweetwater River heads about 10 miles northwest of Stambaugh Peak in the Wind River region. Flowing through cañons of short length and through narrow valleys it emerges from the western slope of the mountains into the rolling metamorphic area. Receiving water from a large number of swift mountain streams, the river has attained a considerable size upon reaching the open country. At first it passes through a number of small cañons, deeply cut into the schists of that region. While within the mountains the river has a course nearly south. This is changed to an easterly one after it has emerged into the open country. Flowing eastward, south of South Pass City, it is crossed by the stage-road. From there on the Sweetwater retains a general course of nearly west to east, varying probably 10 miles on either side in its turns. Approximately the river follows north latitude 42° 30′. After flowing past Camp Stambaugh, about 10 miles south of it, the stream enters what we have called the Little Sweetwater Cañon. It is there inclosed by steep walls of metamorphic rocks. At this point we have reached the southeastern termination of the foot-hills of the range. A vertical rent in the rocks has opened a passage for the stream, which rushes through it with great violence. Descending the rather steep slopes of the hills at this locality, a part of which belong to the older sedimentary groups, we reach the valley proper of the Sweetwater. A few miles below the cañon we find Saint Mary's ranch. This, at the present time, presents but the ruins of an old stage station. From there the river winds eastward lazily through its valley. Bordered on either side by bluffs, the low-land is covered with grass and willow brush. About 15 miles above the Three Crossings we meet with another small cañon. A gap in quartzitic sandstones, sufficiently narrow to force the river through it with a rush, is formed by vertical walls about 120 feet in height. After tumbling over the bowlders the Sweetwater enters a comparatively wide valley, containing an abundance of good grass. By this time we have arrived within the Granite Hills. Bordering the river on the north, they determine, in a great measure, its course. Following down the valley, we eventually reach the Three Crossings, located about at west longitude 107° 45′. Here the wagon-road crosses the stream three times in rapid succession, whence the name. A grassy bottom, about 2 miles in length, is found on the south side of the river, which closely hugs the granitic hills to the north. From that point downward we notice several sharp turns, induced by the projecting or receding masses of granite. In a few instances we find that small gaps have been formed in some of the transverse ridges. Taking advantage of these, the Sweetwater shortens its course by passing through them. Flowing past Cloven Peak, it runs closely along the southern border of the granites, until, finally, it crosses this irregular range by way of the Devil's Gate. This latter is a vertical opening in the rocks, filled almost entirely by the stream. Perpendicular walls enclose the river, rising to a relative elevation of about 400 feet. Immediately after passing through the gate the Sweetwater turns to the northeast for a short distance, thus effecting a crossing through the Granite Hills. By following this turn for about 5 miles we reach Rock Independence, located near west longitude 107°. From there the river flows about 10 to 12 miles farther to its junction with the North Fork of Platte River. It passes through a narrow cañon in a series of rapids. Here it was that Frémont made his memorable trip downstream, in the

rubber-boat he carried with him, which, after successfully passing the greater portions of the rapids, was eventually capsized.

Northern tributaries of the Sweetwater.—While within the mountains, the Sweetwater receives a number of small streams, which rapidly swell its volume. North of South Pass City heads what has been called *Willow Creek*. After a short run this discharges its waters into the Sweetwater. A short distance farther east, near Atlantic City, *Rock Creek* heads, which joins the river nearly south of Stambaugh. Eastward, beyond that point a number of small streams run towards the Sweetwater, but only few of them carry any water for the entire distance. During the wet season many of them flow freely, but they begin to dry up in June. From the plateau we found no water entering the river. A number of small creeks exist within the plateau, issuing mainly from springs, but they do not carry water for more than a few hundred yards. An exception to this rule was found immediately south of the western end of the Granite Hills. There we observed a stream of some size, having a length of about 16 miles. At a number of points water was found in the run, sometimes flowing, at other places stagnant. From what we saw there, we inferred that this creek carried water during a considerable portion of the year. At the mouth of the small cañon 15 miles above the Three Crossings, this creek flows into the Sweetwater. Provisionally, I shall designate it as *Heron Creek*. No tributaries of any importance besides these were found on the north side of the river. The drainage-area of the plateau is not very large, and the character of the strata composing it is such that water easily soaks down into them.

Southern tributaries of the Sweetwater.—Few streams, comparatively, of any size flow into the Sweetwater from the south. Within the hills bearing the same name is the creek on which we camped in the narrow Carboniferous cañon. Rising in the isolated granitic hills south of the river, this creek first follows an easterly course. On its way it receives several small branches. A sudden turn changes its direction to the north, and it enters the Sweetwater about 8 miles below Saint Mary's Station. At the time we were there, June 30, it carried water throughout its entire length. Near its junction with the river the ground is swampy, and we found no well-defined mouth of the creek. This stream we have named *Saint Mary's Creek*. Along the northern slope of the Sweetwater Hills there are a large number of small creeks, which start in the gulches cut into the slope. As a rule, they only run for a short distance, however, soon sinking in the loose soil nearer the river. Wherever the timber extends far down the slope, there the water will remain above ground for some distance. During certain seasons of the year several of these streams discharge their water into the river, but at the time of our visit (August) we found no water farther than a mile from the base of the hills. Still farther east, in Elkhorn Gap, there is a good-sized stream, which carries water to the river. Heading on the south side of the hills, it curves along their base, passes the middle butte to the eastward, and flows through the low gap. Bordered by grassy meadows and receiving additions of water from a few small creeks, this stream runs through a broad valley northward into the Sweetwater. It carries water during the entire year, and, judging from the appearance of the banks, must form a perfect torrent at certain seasons. It has been named *West Sand Creek*. As farther west, so the hill-slope east of Elkhorn Gap contains a number of short creeks. They carry a plentiful supply of water until they emerge from the hills and lose it in the sandy soil northward. At about one-third of the distance from Elkhorn to Whis-

key Gap we found quite a large stream. It was well timbered with cottonwood and showed beautiful glacial moraines on either side. During the larger portion of the year this stream carries its water northward into the river. Near the base of the mountains we find large meadows on the streams, which are generally formed near the conflux of several smaller creeks. Another stream of some size flows northward about 8 miles west of Whiskey Gap. During the distances for which these streams remain within the boundary of the hills they carry clear, good water, but they become alkaline after passing through the strata composing the Sweetwater Group. These two latter streams we have named, respectively, *Glacier* and *Lone Rock Creeks*. Through Whiskey Gap flows *Muddy Creek*. Rising south of the Seminole Hills, it flows first westward and then turns sharply to the north, finally emptying into the Sweetwater. Within the gap the water of this stream is clear, but it soon becomes muddy after leaving the hills. It is crossed by the wagon-road immediately outside of the gap. East of Whiskey Gap we have but one more stream of importance in our district, *Sandy Creek*. It heads along the slope of the Seminole Mountains, flows through a low pass, and enters the North Platte south of the junction of the Sweetwater with this river.

WIND RIVER DRAINAGE.

Wind River does not reach into our district, approaching it only within about six miles. An important portion of its drainage remains within the limits of our district, however. *Little Wind River*, the most prominent branch, heads in the Wind River Range, north of our area, and flows in a southeasterly direction after leaving the mountains. On it Camp Brown is located. After passing the post its course is a little south of east, until it makes an abrupt turn northward and joins the Wind River. This in turn flows in a general northerly direction. The name is retained until it passes through the Owl Creek Range, about north latitude 43° 30′, when it changes into that of Bighorn River. All the remaining drainage belonging to this system, so far as contained within our district, consists of tributaries to the Little Wind River. Two streams are prominent among them—the *Popo-Agie* and *Beaver Creek*. The former rises in the Wind River Range, near Snow Peak. As long as it remains in the mountains it is known by the name of *North Fork*. Flowing in a northeasterly direction, it passes through densely-timbered, very rocky cañons. Steep slopes inclose the streams and carry to it swift mountain streams. Cutting through the foot-hills, it finds egress by way of a comparatively wide opening through the outlying hills of the third chain. Emerging entirely from the hills, it flows through a broad, fertile valley, and finally enters the Little Wind River as Popo-Agie a little south of east from Camp Brown. A stream that in reality is a tributary of the North Fork has been called the *Big Popo-Agie* and *Baldwin's Creek*. It takes its rise in the range south of that of the North Fork, and, following an approximately-parallel course, finally leaves the mountains. While in the lower country, near the eastern edge of the outlying hills, it is joined by a creek coming from a southwesterly direction. Near the confluence of these two streams extensive settlements exist. After the junction of the three creeks, below that of the North Fork and Baldwin's Creek, the stream is called simply the Popo-Agie. Its largest tributary coming from the mountains is the *Little Popo-Agie*. Heading near Stambaugh Peak, this stream flows in a northeasterly direction. After leaving the foothills it cuts through the third chain, finding its way along a very fine cañon. Perpendicular walls, about 800

feet in height, composed of limestone, form a chasm in the outlying hills, through which the stream rushes in a series of rapids and small cascades. From there it enters the hilly area surrounding Sheep Mountain, and finally emerges into the low country, where it makes a sharp turn northward and joins the Popo-Agie. During its course the volume of water is swelled by several smaller creeks. *Twin Creek*, rising beyond Miner's Delight, is forced to make a considerable detour before being able to pass through the outlying hills. After a passage has been effected some distance to the south, this creek flows in an easterly direction. A sharp curve to the north carries it along the western base of Sheep Mountain, and it eventually empties into the Little Popo-Agie about four miles below Eagle ranch. A small creek flowing through the picturesque Red Cañon carries its water into the same stream. Within that area a number of unimportant creeks are found, the largest one of which is probably *Cottonwood Creek*, a branch of Twin Creek. From the west *Willow Creek* flows into the Little Popo-Agie. Most of these small creeks carry water during the entire year, although in some of them it becomes quite muddy during the latter part of the dry season.

Beaver Creek.—This stream heads a short distance east of Camp Stambaugh. Flowing in a direction a little north of east, it runs through a narrow, very pretty cañon south of Sheep Mountain. On its course to that point the Beaver receives a number of small tributaries. Retaining its general course toward the east, the Beaver cuts directly across the younger sedimentary bluffs of that region. A sudden turn to the northward brings the stream into a broad, open valley running parallel with the trend of the bluffs. From there the Beaver flows through low, flat country until finally it joins the Little Wind River.

A large number of creeks start along the steep northern slope of the Sweetwater Plateau. They belong to the Wind River drainage, but except in particularly wet seasons carry no water into it. As a rule, they run but a very short distance, soon sinking in the loose arenaceous soil of the lowlands. Many of them have runs of but a few hundred yards or even less, being in reality nothing more than overflowing springs. A large area of very dry country intervenes between the Sweetwater Plateau and that eastern tributary of the Wind River, *Bad Water Creek*. This latter is beyond the limits of our district.

GREEN RIVER DRAINAGE.

Big Sandy River.—Within our district the Big Sandy is the main stream flowing into Green River. It rises northwest of Snow Peak on the western slope of the Wind River Range and flows in a general direction west of south. Passing through the mountains it has the character of a swift mountain stream, carrying a considerable amount of water. Its channel is generally very rocky and the clear water leaps over huge bowlders often forming a perfect torrent. Upon leaving the mountains it shows a succession of rapids and cascades while rushing through a narrow cañon in the subsidiary granitic range. From there it flows more slowly along the Tertiary bluff country lying between the base of the mountains and Green River. This latter stream it joins in about north latitude 41° 48′. The Big Sandy, well known in the early history of this section of country, has several tributaries to the eastward. Travelling in that direction we first meet with *Little Sandy Creek.* It rises at the immediate western base of Snow Peak, and flows for some distance through a narrow, very pretty cañon, until it empties into Barret's Lake. From there its downward course is rapid. Leaving the

mountains it cuts through the granitic range outside and enters the low country. Losing much of its water there, it finally enters the Big Sandy as a muddy stream, very wide but shallow. A few small creeks run into this stream after it leaves the mountains, but they mostly carry water only a short distance, except during the wet season. Proceeding a few miles farther east we find the *Dry Sandy*. This is a branch of the Little Sandy, and, as the name implies, only contains water temporarily. Flowing for nearly its entire length through a dry, sandy country, the supply received from the mountains is soon exhausted, and nothing but a wide bed filled with yellow sand denotes the course of the stream. *Pacific Creek*, located a short distance farther east, is a tributary of the Dry Sandy. Rising at Pacific Springs, this creek flows in a southwesterly direction. It contains water through a large portion of its course, although it is very alkaline. Father south there are several other streams carrying water during some seasons of the year. *White Horse Creek* is one of these.

Muddy Creek.—Near the northwestern corner of our district is a good, sized stream indicated by some maps as Muddy Creek. It takes its rise near that depression in the Wind River Range over which the Shoshone trail leads. Flowing to the southwest, it rapidly changes its course to a westerly one upon emerging from the mountains and passes out of our district.

Packer's Creek.—A short distance west of Salt Wells Station, on the Union Pacific Railroad, we find a long creek, having its course through a wide, nearly straight valley. Its direction is approximately southward and it forms a junction with Bitter Creek near the station above mentioned. During the summer the lower portions of this creek are dry and water can only be found in small stagnant pools.

Sulphur Creek.—Near Point of Rocks, Sulphur Creek joins Bitter Creek. Some of its northern branches extend into our district. While most of them are dry, others contain water at local intervals. The southwestern corner of the district is very poorly watered, and the traveller must depend in a great measure upon finding springs or small alkaline pools. By following the drainage-courses the latter can frequently be found.

DRAINAGE SOUTH OF SWEETWATER HILLS.

Without the aid of an accurate map it becomes an exceedingly difficult task to convey any definite idea of the hydrological conditions of this region. No well-developed system of drainage exists there, and the distribution of elevations and depressions varies materially from that observed in other portions of the district. The continental divide through that section of country follows a line about east 45° south. Accepting that position and direction for it, it is determined by the headwaters and upper drainage of Pacific, Packer's, and Sulphur Creeks. At all points within this region the "backbone of the continent" is so low and generally obscure, that it really requires careful attention to recognize it. Looking eastward from any point of this divide we find the streams apparently flowing in such a way as to join Atlantic drainage. Upon examination, however, we here find an extensive depression into which water is carried from both east and west, only to sink. The shape of this depression is approximately oval, and is located near the one hundred and eighth meridian. Although scarcely anything but dry washes are met with in this region, it contains quite a number of lakes of various sizes. Within their immediate vicinity small creeks may

sometimes be found, owing to a saturation of the subsoil, whereby the water is enabled to remain upon the surface. Without reliable hypsometric data, it is scarcely possible to recognize the character of this entire region unless the whole of it has been seen. Were flowing water contained in the channels that now appear only as dry gulches, the recognition of the characteristics here exhibited would be somewhat facilitated.

Considering the peculiar position of this basin, between the drainage of Green River and that of the Platte, it remains rather doubtful on which side of the depression, east or west, the continental divide should be located. Considering that the western drainage is perhaps more pronounced than that to the east, I have given preference to the western rim of the basin. For the purpose of facilitating subsequent description I shall apply to this extensive "sink" the provisional name of *Shoshone Basin.*

LAKES AND SPRINGS.

Lakes.

Wind River Range.—On the eastern slope of this range we find a large number of lakes within the granitic area. Most of them are small. Dependent upon their position, either in cañons or on ridges, they are deep or shallow. Perhaps the most picturesque one that we met with during our trip through that region is the one upon which we located our thirty-seventh camp on July 18. Situated at the lower end of a wide green valley, bordered on either side by ridges that rise above timber-line, this lake surpasses in beauty of surroundings any we saw on the eastern slope of the range. Its elevation is about 10,000 feet above sea-level. Game and the striking scenery render the lake a most desirable place for camping purposes. In order to commemorate, to some extent, our stay of two days at that locality, and to give expression to our appreciation of the vicinity I have given this sheet of water a name, *Lake Christina.* Surrounded by steep rocks and dark timber, many of the smaller lakes appear very pretty. The western slope of the range does not, perhaps, contain so many lakes, but those we found there were very characteristic. Prominent among them is *Barret's Lake*, on the Little Sandy. Apparently surrounded on all sides by precipitous, rocky slopes, this body of water is completely secluded, well hidden from the observation of the casual traveller. Its depth seems to be very considerable, a fact which is indicated both by the character of its shores east and west and by the measurements some fishermen took there. Higher up in the range, and farther north, are many small glacial lakes. They have been either formed by a dam composed of glacial drift, or they occupy shallow depressions produced by the abrading action of the moving ice and its accompanying bowlders. Surrounded by rocky slopes and scattering timber they present a very definite character.

Shoshone Basin.—Within the area forming this depression a large number of lakes or lake-beds were observed. Usually they occur in groups, each individual lake only separated by a short distance from the other. Prominent among them is one that we name *Trail Lake*, from the proximity of the Shoshone and Ute trail. It is about a mile and a half long and half a mile wide. To the north and northwest of Trail Lake there are quite a number of others, furnishing a favorite resort for numerous antelopes. Farther toward the east is another series of lakes. This was discovered by Frémont during his second expedition in 1843. It is located nearly due south of Elkhorn Gap, about 25 miles dis-

tant. All of these lakes are shallow and more or less alkaline. During the dry season, the majority of them dry out, leaving white, frequently soft, alkaline "flats." The largest lake of the eastern group we have named *Death Lake.*

Sweetwater region.—In the vicinity of the Sweetwater, a number of lakes may be found during the wet season. Very few of them had any water at the time we were there. As the river is so near by, they are of little importance to the traveller. Their water is scarcely fit to drink when it is low, and its existence is not to be depended upon during a large portion of the year. Interesting and comparatively well known to western explorers is the region of *Agate Lakes.* They are located in the immediate vicinity of the river, north of it, opposite Elkhorn Gap. At that locality moss-agates are scattered in profusion over the soil, whence the name.

Dispersed throughout the entire area of low country within our district we find isolated lakes. Unfortunately they are mostly dry during the summer, but early in the season their presence renders travelling "across country" more comfortable than after the beginning of the month of July. In the sand-hills south of Sandy Creek Pass a number of small lakes were found. The loose material has, in the course of time, become sufficiently packed to resist their sinking.

Springs.

Cold Springs.—Within the dry region south of the Sweetwater Hills the existence of springs is often an item of personal interest to the travellers. It is scarcely possible, however, to furnish any rule expressing the conditions under which they there make their appearance. Frequently they occur near the lakes, and, although the latter may be dry, water can often even then be found in the springs. An unusually green growth of vegetation generally indicates their presence. Near Mount Essex we found a spring of this kind at the southern base of the hill. At the foot of a hill upon which station 25 was located, a spring occurs amid the basaltic rocks, and one lower down in a small meadow. We named the former *Basalt Spring.* On the road from Whiskey Gap to Rawlings, *Bell's Spring* furnished a favorite camping-place, and on that from Sandy Creek Pass to Rawlings *Brown's Spring* answers the same purpose. *Cherokee Springs,* near the town, supply its inhabitants with water. Not unfrequently springs may be found along the borders of the "sand-belt," which extends from Packer's Creek to the Seminole Mountains.

On the steep northward slope of the Sweetwater Plateau springs are quite numerous in the narrow gulches which furrow its face. Usually they are of considerable strength, and send their water a short distance as small creeks. Within the Granite Hills springs may be found near the bases of some of the more isolated points. During the hot season the majority of them is dry, however.

In the mountains and along the foot-hills springs are of frequent occurrence. Two very pretty ones were found at Sheep Mountain. One of them was located on the south side of the mountain in the canon of Beaver Creek. Clear, cold water issued from a seam in strata of Carboniferous limestones. The other exists at the northern base of the same mountain, near Twin Creek.

The mud springs at Death Lake may be mentioned in this connection. Although furnishing no drinkable water and not obeying the same laws which usually govern the emission of water upon the surface, they afford

a most interesting subject for study. In subjoined pages their character and mode of appearance will be more fully discussed.

Two springs of petroleum occur within our district, one on the Little Popo-Agie below the junction of Twin Creek, and the other near Camp Brown.

Hot springs.—The most famous hot spring we met with during the season is located about two miles distant (west) from Camp Brown. It is a very large one, of oval shape, about 315 feet in length and 250 feet in width. Its average depth amounts to about 18 feet. As a resort for rheumatics and other invalids this spring is quite famous. The high temperature of its water—108° F.—and the mineral constituents held in solution appear to exert a very beneficial influence. The second hot spring was found near the Beaver Cañon, south of Sheep Mountain. It is known as the *Hot Sulphur Spring.* A small basin existed there, enlarged but very little by human hands, and the warm water continually appeared to be bubbling up into it. Sulphuretted hydrogen gas caused the bubbling and made itself decidedly noticeable in the entire vicinity. We found the temperature of this spring to be 96° F. In the geological report further details referring to these occurrences will be given.

Mineralized springs.—As cold mineralized springs we may regard those containing alkaline water. As this is rather the rule, however, than the exception in a region so thoroughly impregnated as that where the most important springs occur, there is no necessity of especially enumerating them. One which might truly be called a mineralized spring was found near the Hot Sulphur. Issuing from limestone strata, it contained considerable amounts of alkali, ferric compounds, sulphur, carbonic acid, and sulphuretted hydrogen gases.

INDIANS.

Within our district lies a portion of the reservation ceded to the Eastern bands of Shoshones and Bannocks by the treaty of July 3, 1868, and June 23, 1874. While the former reserved for them an area reaching southward nearly to Camp Stambaugh, the latter restricts their southern boundary to within about 6 miles south of Camp Brown. Their agency is located about 4 miles from the post. Annually the White River Utes make a hunting and trading trip northward to their allies, the Shoshones. They travel by what is known as the Ute trail, which leads northward in the vicinity of Washakie Station and passes Trail Lake. Bands of the northern hostile Indians sometimes travel up Beaver Creek, and in several instances, three and four years ago, have interfered with the settlers of the Popo-Agies. Seminole and the eastern end of Sweetwater Hills were formerly favorite hunting-grounds, but of late years the Indians, Cheyennes, Arapahoes, and Sioux have not been regular in their annual expeditions to these localities.

During the summer we met with a number of the Shoshones or Snakes. They stand in tribal relationship with the Northern or White River Utes. For a long time they have behaved very well, retaining friendship with the whites and rendering efficient service in doing scouting duty to military expeditions. In General Crook's last campaign they have distinguished themselves by their fidelity and attachment to the white men commanding them. The venerable Wash-a-kie, their head chief, has been a staunch friend of white men for many years. To his wise counsel and the influence he exerts over the bands composing the Shoshone tribe is due, in a great measure, the friendly footing which has been maintained between them and the neighboring white settlers.

In physical appearance and dress the Shoshones seem to be superior

to their friends the White River Utes. They have clung more tenaciously to their typical mode of clothing themselves, and their weapons are more characteristically Indian. Tomahawks—manufactured in Connecticut—are frequently seen among them, while the Southern Indian has almost entirely discarded this weapon of offense. Bows and arrows they often carry, besides rifles, with which they are well supplied. About their habits little can be said; they differ but slightly from those of other Indians, and are, as usual, greatly modified by the imitation of and proximity to white men. Their religious exercises and beliefs are strictly carried out and carefully guarded from the knowledge of white men. It is "bad medicine" to allow them to become common property, and many a superstitious fancy is connected with the fear of the evil that a possession of their knowledge by whites would bring the Indians.

SETTLEMENTS.

A numer of settlements occur within the district we surveyed. They were organized within the past 12 years, and owe their origin to various pursuits. Mining and agriculture have attracted the largest proportion of settlers, while hunting and the establishment of stage lines has been productive of isolated habitations.

Mining settlements.—The settlements produced by the prosecution of mining industries are located in the vicinity of Camp Stambaugh. *South Pass City*, 6 miles southwest of the post, was started in 1867, and during the early mining excitement of that region a large number of houses were built. The town is located in a narrow gulch on Willow Creek, a tributary of the Sweetwater. Since the mines have largely been abandoned the inhabitants have gradually left there, seeking localities where either labor or merchandise were in greater demand. At present the place looks very much deserted. A few stores, two hotels, and a small number of dwellings unoccupied comprise the city. *Atlantic City*, two miles from Camp Stambaugh, was started at the same time as South Pass. It had reached a smaller development, however, and, owing to the vicinity of the post, it has suffered less. In case the mining prospects should become brighter, both of these towns may rapidly increase again. North of the post is *Miner's Delight*, a small mining town located on a tributary of Twin Creek. Mining is still carried on there to a small extent, but the first flush of success is over. The location of this place is very pretty, high up in the lower foot-hills, commanding a fine view both to the north and east. All of these three places are on the stage line from Bryan's Station on the Union Pacific Railroad to Camp Brown.

Agricultural settlements.—Following from Miner's Delight the stage-road northward we first reached Red Cañon. Here some farming is done on Tweed's ranch. From there we reach the Little Popo-Agie. A "garden" established by Camp Stambaugh, Faris' ranch, and Murphy's ranch occupy the narrow but fertile valley of this stream. They extend downward to the junction of Twin Creek. To the southward we find a ranch located on the Coltonwood, a branch of Twin Creek. Continuing on the stage-road for twelve miles from Murphy's ranch we reach *Lander's City*. This town is established near the point where Old Camp Brown was formerly located, on the Popo-Agie. Extensive farms are worked here, and a bountiful supply of timber, for various purposes, is obtained from the neighboring foot-hills of the Wind River Range. The farms are in a flourishing condition and bid fair to prove a good investment of the labor bestowed upon them. On the North Fork and on the Little Wind River, below Camp Brown, are a number of ranches. On

Sandy Creek, in the Seminole Mountains, the beautiful valley of that stream is utilized, in part, for farming purposes. Hay is cut at a number of localities for supplying the demand created by the existence of the military posts, and for shipment to the railroad. In the small valleys of the foot-hills near the southern termination of the Wind River Range good hay is found, more especially on the Sweetwater drainage. In some of the valleys on the northern slope of the Sweetwater Hills, west of Whisky Gap, hay is obtained, and also in the meadows of Sandy Creek Valley. Near the lakes within the sand-hills south of the Seminole Hills grass grows in great abundance, and is cut. The short distance from there to Rawlings, about 42 miles, renders that region very eligible for such purposes. Much more could be obtained, if the demand warranted the transportation, along the Sweetwater River. On the Wind River drainage it is cut to supply the stock of the settlers and Camp Brown. Timber is obtained in good quality and large quantities from the foot-hills of the Wind River Range. From convenient points there it is either floated down in the streams or carried by axle. If the population of this section of country should increase, the region of the Popo-Agie and of its tributaries would be able to supply the demand of farming-products for a long time. Climate and soil are both favorable, and it requires but the industrious hand of man to prepare the latter in such a way as to yield him its tribute.

Stage stations.—Along the Sweetwater we find the ruins of the old overland stage-route. At present the road is almost entirely deserted, and nothing now remains but a few walls, stumps of telegraph-poles, and some wire. The only mail-route now in active daily operation within our district is that from Bryan Station, on the Union Pacific Railroad, to Camp Brown. On the Big Sandy there is the first station, on the Dry Sandy the second, and the third at Pacific Springs. From there the stage-road passes through South Pass and Atlantic cities, Camp Stambaugh, and Miner's Delight. Beyond that town the next stage station is at Murphy's ranch on the Little Popo-Agie, and the last one before reaching Camp Brown is at the Landers City settlement. Stages leave Bryan daily. Between Rawlings Springs and the settlement on Sandy Creek a riding mail has been established, making the trip, over 50 miles, in one day.

Hunting camps.—Permanent hunting camps for the season are found mainly on the northern slope of the Seminole Hills. They are but few in number, however. Fishing and hunting is professionally followed on the western slope of the Wind River Range during certain seasons of the year.

MEANS OF COMMUNICATION.

Wagon-roads.

North and south.—The most prominent wagon-road in our district is that running from Bryan Station to Camp Stambaugh. It is used daily by the stage, and all freight for the settlements passes over it. Emigrants to the Bighorn Mountains utilize this road as the easiest and shortest from certain regions. Passing all the towns of the mining and agricultural regions, it is a road of great importance. Grades are easy and the road-bed is in good condition. A branch separates a short distance north of the Big Sandy Station, and following a southwesterly direction leads to Fort Bridger.

From Camp Stambaugh an old wagon-road, scarcely ever used at

present, passes through the bluff country. It follows a southward course and reaches Point of Rocks. On some maps it is designated as the "proposed route." West of it is a very old road, deeply worn down into the soil, which leaves the Sweetwater River and reaches Fort Bridger. This is now entirely superseded by the stage-road. A number of short cross-roads, running into the others at acute angles, form connections between them.

East of Elkhorn Gap a road leaves the Sweetwater, gradually approaches the hills, and turns southward through Whisky Gap. It follows along Muddy Creek for some distance, and finally reaches Rawlings Springs. On the way it passes Bell's Springs. Starting also from the Sweetwater, near Rock Independence, a road leads through Sandy Creek Valley, crosses over the pass, and enters the sand-hills. Retaining for some distance a southerly course, the road emerges from the sand and passes through the alkaline country in a direction a little west of south. Passing Brown's Spring, it finally reaches Rawlings. These are the main routes of communication within our district having a north and south course.

East and west.—Near Washakie Station an old road is crossed by the railroad. From that point it follows a northwesterly course until it reaches a comparatively easy country. Then it strikes westward, finally reaching Green River and crossing over to Bryan Station. This road is designated on maps as the "old overland mail-route," or as "Evans' old route." Wherever we found the road it was still plainly discernible, although only very rarely used. More important, perhaps, than this road is that along the Sweetwater River. Followed for a long number of years by emigrants, the road is still more or less in use. We reached the eastern terminus of our district on this road. From there westward it continues nearly always in the immediate vicinity of the river, leaving it in a few instances for a short distance. From Rock Independence it follows up-stream on the south side of the river. Passing the Devil's Gate, it remains on the same side. After leaving the ruins of the stage-station at the Three Crossings, it remains on the north side of the Sweetwater, but soon crosses over to the south again. At that locality the river makes a northward bend, while the road, leaving it, keeps ahead in a straight line. At Saint Mary's Station it again is found in the river valley. Continuing westward, on the north side of the Sweetwater, the road forks beyond its crossing of Rock Creek. One of the branches keeps along the base of the Wind River Mountains at first, but gradually leaves it, however. The other follows a course south of west, leading through the low bluff country. Of these the latter is known as the "old emigrant road" or "Oregon trail," while the former is known as the "new emigrant road." Both of them cross, successively, the Sweetwater River, South Pass, and the various branches of the Big Sandy. Frémont, during his expedition of 1842, traveled for some distance along the new road, and later took the old one. Near the settlements numerous local roads are found, connecting either with habitations or are utilized as hay-roads and wood-roads.

We find, from this arrangement of traveling routes, that our district is traversed from north to south by three good roads. The most westerly one of these follows approximately along from west longitude 108° 40′ to 109° 40′; the middle one is nearly on longitude 108° 45′; and the eastern one near west longitude 107° 25′. From east to west it is traversed by two roads, the nothern one following along north latitude 42° 30′, and the southern one near latitude 41° 50′.

Trails.

Comparatively few trails are found within our district. Perhaps the most important for extensive travel is that known as the "Ute trail." Passing the railroad near Washakie Station, it follows a direction west of north. Leading through the low, dry country, it strikes the group of lakes of which Trail Lake is the largest. From there it continues its course, although much obliterated, to Camp Brown. As the wagon-roads frequently follow the same route formerly taken by the trail only, it now appears at several places as "cut-offs." It is used a good deal by the Indians, who pass over it while making their visits to each other. Within the low country we find a few short trails leading up cañons or crossing some of the ridges. Although of some assistance in riding through the region, they are of no further importance. Along the northern slope of the Sweetwater Hills there are some isolated hunting-trails. The wagon roads of that vicinity are so old, that they have been utilized to the utter neglect and consequent obliteration of the trails that may have existed there. A good trail is found following down Beaver Creek. It appears to be a branch of that leading from Washakie to Camp Brown. Several ramifications pass through the cañons of the Sheep Mountain region. Important to the Indians, although rarely used by white men, is the trail crossing the Wind River Range. Coming from the west it reaches the mountains near the exit of Muddy Creek. Following along a cañon to the northwest of this stream it finally reaches timber-line, at the base of a peak which we have named Temple Peak Again descending, it crosses the Muddy. Winding along the rugged hills it once more emerges from the timber and crosses the continental divide at an elevation of about 11,600 feet above sea-level. From there it descends rapidly and leads to the agency near Camp Brown. This pass is known by the name of "Shoshone Trail Pass." So far as our observations extend, it is the most southerly practicable pass across the continental divide for the distance that this is formed by the Wind River Range.

VEGETATION.

With the topography of our district varies its vegetation. It is not my intention to present a synopsis of all the plants occurring in the regions we have traversed, but merely to indicate the most prominent forms there exhibited by the flora. For comprehensive information upon this subject I refer the reader to Frémont's Report, 1845, and to the Report of Dr. Hayden, 1870.

In the Wind River Range, at the highest point reached by timber we find the characteristic pine which grows at this elevation. Within the mountains spruce trees (*Abies menzinii*) and firs (*Abies subalpina*) compose the main portion of the timber. As we descend, we meet with the yellow pine (*Pinus ponderosa*), which forms very pretty groves. At the same elevation we find quaking asp (*Populus tremuloïdes*). On some of the ridges, and along cañons that contain a good deal of moisture, these trees reach a very considerable height. Their light-green foliage and the white trunks present a very pretty appearance. On the lower, outlying bluffs *Pinus contorta* occurs frequently. As we descend from the foothills the character of the vegetation changes. The creeks are densely fringed with willow-brush (*Salix nigra*), which, together with quaking asp, furnishes desirable food for beavers. Reaching the bluff country we find sage-brush (*Artemisia tridentata*) very prevalent. Its appearance usually indicates a dry, sandy region. On some of the bluffs of the

lower country we find piñons (*Pinus edulis*) and cedars (*Juniperus virginianus*). In the hills near Sheep Mountain we observe the same trees, prominent among them the white pine (*Abies Engelmanni*). All that low country lying east of the Wind River Mountains and north of the Sweetwater Plateau contains sage-brush and cactus (*Opuntia*). On the bluffs cedars and piñons are very prominent. Cottonwood trees (*Populus balsamifera*) line the rivers or streams, and grease-wood (*Sarcobatus vermiculatus*) is mixed with sage-brush. On the Sweetwater Plateau but very little timber occurs, excepting on its northern slope. There pines and quaking asp are found in the gulches, while sage covers the intervening ridges. On the southern slope of the plateau bunch-grass (*Eriocoma cuspidata*) is abundant, affording good feed for the animals. Along Sweetwater River there is but little timber, consisting of cottonwood and some spruce higher up. Willow-brush, growing quite high, lines the river. In the granite hills we find scarcely any timber, only a few pines. Although the elevations at a number of points in the regions mentioned were often quite low, we met with no wild fruit except service-berries (*Amelanchier alnifolia*). On Sandy Creek we found large quantities of yellow currants (*Ribes aureum*) and some black ones (*R. floridum*). Gooseberries (*Ribes hirtellum*) occur at several localities, but do not ripen until late in the season. Both the Seminole and Sweetwater hills are well timbered with spruce and pine. Cottonwood and asp are found in the gulches and low valleys existing in the hills.

Very little variation is observed in the vegetation of the low country south of these hills. Sage-brush occupies the most prominent place, growing frequently to very large size. Cedars appear occasionally on the bluffs, and near some springs we found quaking asp. Prickly pears and round cacti (*Echinocactus*) render travelling rather unpleasant at some localities within this region.

Good timber can be obtained from the foot-hills of the Wind River Range on its eastern side, or along its western slope. Within the Sheep Mountain Group there is a plentiful supply, but transportation from there becomes difficult. Both in the Sweetwater and Seminole Hills timber is abundant, and the configuration of the country is such that its removal is not seriously impeded. In the Granite Hills the few trees there existing are generally stunted, but for building purposes would answer tolerably well. No available timber exists in the low country south of the Sweetwater Hills or in that north of the Sweetwater Plateau. No inducements are there offered to settlers, however, by the character of the country, and it is not likely that a demand for timber will arise. Light timber can be obtained from the lower portions of the Wind River foot-hills and along a number of streams in that section of country.

GAME.

Game is abundant in the district which we surveyed. From June 12 to the end of the season we were never without fresh meat, although we made no especial efforts to obtain it, but merely shot the game when we happened to meet it. Each different type of country is inhabited by different animals; and our food was varied, therefore, in accordance with the character of the country through which we travelled. Buffalo, the largest North American mammal (*Bison americanus*), were found at two localities. On the Little Sandy we met a solitary old bull, who had for some time evidently regarded that region as his private stamping-ground. On the Sweetwater Hills we saw quite a number of these animals. During September and October, sometimes a little earlier, they

pass there on their way southward. During the time we were there (September 7) the largest band seen amounted to about 70 head. Elk (*Elaphus canadensis*) occur both on the eastern and western slope of the Wind River Range. Again, some were seen near Sheep Mountain. Generally they run in bands, numbering, during the summer, from 10 to 60 animals. Later in the season they collect together, forming large herds. By that time the calves are strong enough to travel with the others. On the Sweetwater, above the Three Crossings, some were met with. Throughout the Sweetwater Hills, they can be found during the entire year. In fall and winter they are very abundant there, as well as at the small groups of lakes farther south during the latter season. East of Sweetwater Gap we saw a single herd containing over 400 elk. At that time they had just begun to come south. Hunters state that herds of several thousand can be found in this region during the winter. Black-tail deer (*Cariacus macrotis*) are found throughout nearly all the mountains and hills. On the western slope of the Wind River Range they are plentiful. On the northern face of Sweetwater Plateau, and in the hills near Sheep Mountain, they can usually be found in small gulches containing quaking asp; lying quietly in the shade during the heat of the day, they come out of their shelter morning and evening. Along the Sweetwater and Seminole Hills, wherever these are timbered, black-tail are quite abundant. White-tail deer (*Cariacus virginianus*) are rare in our district, and were seen only once, about 8 miles to the southwest of Mount Essex. Sage-brush occurred there of gigantic size, mingling with scattered cedars; and the deer were found in these. Mountain sheep (*Ovis montana*) were found at several localities. They were met with on the eastern slope of the Wind River Range, above timber-line. At the base of Stambaugh Peak, at timber-line, we struck a band of more than 100 sheep. Some that were there shot (July 25) showed an exterior coat of fine, light-gray wool, about half an inch in thickness. At that time they were shedding this wool. On Sheep Mountain and in the Granite Hills a few sheep were seen. Antelopes (*Antilocapra americana*) are by far more numerous than any other kind of game. During the season we saw, probably, at a low estimate, 8,000 of them. In June and July they are shy, and good shots cannot be obtained without using considerable precaution. Later in the season they become bolder and congregate in large herds. Bands numbering several hundred may frequently be seen. The greatest numbers of these animals we found near the lakes of the Shoshone Basin, on both sides of the Sweetwater and Seminole Hills, and on Sweetwater River. In August and September they are easily shot, owing to their investigating turn of mind, which causes them often to approach a strange object within a short distance.

In the Wind River Range we found a number of the mountain rabbits (*Lepus americanus*, var. *bairdii*). This is the prettiest rabbit of the West, and the best one for culinary purposes. During the summer it is of a dark grayish-brown color, light yellow underneath, but in winter turns white. Jack rabbits (*Lepus campestris*) occur wherever sage-brush is found. Their long ears and peculiar, jumping run render them a very ludicrous sight. Cotton-tail rabbits (*Lepus sylvaticus*, var. *nuttalli*) are very frequent in the bluffs adjoining rivers and streams. Even a long distance from water, however, they may be found. Their meat has an insipid taste.

In the mountains and some of the foot-hills, the blue grouse (*Tetrao obscurus*) form an important portion of the game. During the fall their meat is better than that of any other game bird. Lower down, along

creeks and streams, we find the willow-grouse (*Lagopus leucurus*), often occurring in large flocks. Sage-fowl (*Centrocercus urophasianus*) are exceedingly numerous in the sage-brush country. Dependent upon a water supply, however, they rarely travel far from either springs, lakes, or water-courses. We saw flocks, more particularly on the drainage of the Big Sandy, that numbered over 100 birds. Owing to their food, buds and leaves of sage, the meat of this fowl is frequently bitter. Prairie-chickens (*Pediœcetes phasianellus*, var. *columbianus*) occur sparingly in some of the grassy meadows on the Sweetwater. Wild geese (*Branta canadensis*) were found in large numbers on the lakes of the Shoshonee basin, and on those occurring in the sand-hills south of the Seminole Hills. In one instance we saw them high up in the mountains, near the Shoshonee trail. Together with them we usually observed large numbers of gray ducks (*Chaulelasmus streperus*) and of "red-heads" (*Fuligula ferina*, var. *americana*). Diver-ducks (*Mergus*, sp.) and coots (*Fulica americana*) generally occur with them. Along the shores of the lakes we may see great numbers of various sand-pipers (*Tringa* spp.). Occasionally a heron makes its appearance. On the Sweetwater many ducks and some geese are found.

A few other animals, not exactly ranking as game, may be seen in considerable numbers in our district. Prominent among these is the grizzly bear (*Ursus horribilis*). In the Wind River Mountains we saw two specimens, and one in the Seminole hills. We never had occasion to verify their reputation for ferocity, finding that after the first shot they generally ran away. Squirrels, both red and gray, are found in the timber. Porcupines (*Erethizon epixanthus*) were often met with on the western as well as eastern slope of the range. We noticed that they reached up nearly to timber-line. Ground-hogs or rock-dogs (*Arctomys flaviventris*) reach from the lower foot-hills to some distance above timber-line. Their shrill, penetrating call can be heard for a long distance, but it requires careful and patient watching to get a good shot at them. Brown martens (*Mustela americana*) have their habitations near pine and spruce timber, but are difficult to shoot. Above timber-line we find large numbers of the little marmot (*Lagomys princeps*). Rendered very tame by their seclusion, they often crawl out of their rocky homes and attentively watch the unusual operations performed by a surveying party within their domains. They are exceedingly graceful little creatures, and their squeaking chirrup is the only sound heard at very high altitudes. Within the mountains we find, rarely, the red fox (*Vulpes fulvus*, var. *macrurus*). Shy and wary, he easily evades the hunter, and must be trapped. Among the foot-hills of the range, and in the Sweetwater hills, beaver (*Castor canadensis*) are numerous. Their dams and the work they perform on trees and shrubbery in the vicinity of their habitations is almost the only evidence of their existence that is ever seen by the traveler. It is an exceedingly rare occurrence to see a beaver during day-time. In the foot-hills, particularly in meadows, skunks (*Mephitis mephitica*) are sometimes met with. Their presence is not desirable, although the animal is a very pretty one. Wolves (*Canis occidentalis*) are said to occur in the same regions, but we saw none of them during the summer.

Descending into the lower country we find an abundance of prairie wolves, or coyotes (*Canis latrans*). Following the herds of antelope and buffalo they catch the sick members thereof, thus eking out an existence of questionable happiness. They are rarely seen except where game is in the neighborhood. Badgers (*Taxidea americana*) are frequently found along the streams of the low country, living in more or less extensive

colonies. They are very hard to kill, and "show fight" to their last breath. The red fox was observed a number of times on Sweetwater River, watching for young sage-hens. Black martens, or fishers (*Mustela pennanti*), were seen on the same stream. Typical for the low, sandy country, and its accompanying sage-brush and cactus, are the prairie dogs (*Cynomys ludovicianus*), replaced in similar resorts in the mountains by the distinct *C. columbianus.* Living in more or less extensive settlements, both these animals always appear to be busy running from one hole to another. A small brown owl (*Speotyto cunicularia* var. *hypogæa*) lives in the same settlement with them and appropriates such holes as have been abandoned. In the same regions we find many specimens of the little striped and spotted gopher (*Spermophilus 13-lineatus*), a most graceful animal. Less agreeable to the traveler is the rattlesnake (*Crotalus confluentus*), which occurs often in very large numbers in these dry localities.

Sand-hill cranes (*Grus canadensis*) and a few specimens of the blue heron (*Ardea herodias*) were seen on the Sweetwater River. They are exceedingly shy, and it requires patient labor to get within good rifle-shot of them.

CHAPTER II.

GEOLOGY OF THE WIND RIVER RANGE AND COUNTRY EASTWARD.

WIND RIVER RANGE.

As a portion of the Rocky Mountain system, the Wind River Range occupies an important position. Separating the drainages of large rivers, and forming, as it does, the continental divide for some distance, it is one of the key-points to the proper interpretation of our early geographical evolution. No question, perhaps, pertaining to the broad views engendered by the accumulating knowledge of our West, is more important, more fraught with interest, than that bearing upon the geological age of the Rocky Mountains. Until the entire system is fully known, until the results of careful explorations are available, we are forced to base our hypotheses upon this subject on disconnected, necessarily incomplete, evidence. Few of the ranges composing the central chain of the Rocky Mountains afford so remunerative a field for study as that of the Wind River.

Within the range proper the geological and geonostic features are simple, but the eastern base shows arrangements and disturbances that would require months, rather than days, fully to be worked out.

STRUCTURE OF THE RANGE.

While discussing, in previous pages, the topography of our district, the physical appearance of the Wind River Range has been touched upon. It will be remembered that it can appropriately be divided into three chains. Of these the main or western chain comprises the most elevated points and forms the divide; the second is composed of the foot-hills, and the third is made up by the outlying hills along the base of the second. During Frémont's first expedition he traveled along the western base of the range, from its southern termination to Frémont's Peak. His course lay, essentially, between the mountains proper and that which has above been designated as the western subsidiary range. His description of what he terms the "central chain" is very graphic and, so far as he has seen it, correct. As the most prominent southern point of the range we must regard Stambaugh Peak. Rising to an absolute elevation of 12,700 feet, its sharply-cut form and well defined ridges mark it as an important feature in the landscape. From there northward we find that the main chain is marked by peaks of nearly uniform height, reaching about 13,000 feet. Within the limits of our district two points rise considerably above this general summit-niveau: Snow Peak, 13,400 feet high, and Temple Peak. In cross-section this western chain might appropriately be compared to a single saw-tooth. Falling off comparatively gently toward the west, its eastern slope is one of remarkable declivity. So high, indeed, is the angle of this slope that

not unfrequently the rocky faces are overhanging. As is usually the case in mountains of so rugged a character, so here, too, we find that numerous "amphitheatres" have been formed. Steep slopes descending from three sides inclose a more or less regularly shaped area of small extent. Enormous masses of avalanchial *débris* and numerous small lakes render the scenery within these depressions singularly wild and beautiful. The cañons on the east side of the main chain are very steep, affording but rarely sufficient room on their walls for the growth of timber. A series of cañons running parallel with this chain effectually produce its orographic separation from the second one.

The chain of foot-hills directly east of the main chain presents a somewhat different structure. Spurs starting from the latter are disconnected by the formation of deep, precipitous "saddles." Rising from these the foot-hills reach about to timber-line, or for several hundreds of feet above it. Timber-line here follows an elevation of about 11,000 feet. From these highest points the ridges, as well as the valleys between them, extend eastward with but gentle slopes for some distance. After that they fall off steeply. Looking up toward the summit of the range from the base of these foot-hills, little will be seen, therefore, but the sharp ends of ridges jutting out in comparatively regular arrangement. Often the valleys separating the higher portions of these cross-ridges are swampy, affording an excellent abode for the millions of mosquitoes which infest that region. A number of the ridges may be connected with each other by elevated portions trending parallel with the main axis of the range. Deep cañons, cutting across the foot-hills, permit the escape of drainage from between the first and second chains. Precipitous and steep near their upper ends, they gradually widen and grow less impassable. The streams passing through them receive large supplies of water from the ridges which they separate.

After the first impulse of steep eastern descent is passed, the ridges exhibit a more gradual slope in that direction. Secondary and tertiary ridges are formed upon their slopes, and small streams flowing toward the east are numerous. Owing to the character of the rocks, many lakes have been formed, imparting a most pleasing effect to the view. Following the descent of the foot-hills, which gradually becomes more gentle, we find ourselves confronted by steep westerly slopes of outlying hills by the third chain. The drainage of the secondary and tertiary ridges above mentioned, here turns either to the north or south, joining forces with those streams which have passed through the foot-hills in cañons. In one instance, that of Twin Creek, the presence of the third chain forced the main stream to make a considerable detour before it could resume its easterly course. In speaking of the third chain in previous pages, it has been compared to the characteristic "hog-backs" of other regions. Both by their analogous position, and by their stratigraphical condition, is this analogy established. The once-continuous chain has been either cut by the drainage, or the strata composing it have parted under the influence of some enormous strain; in the latter instance, causing the formation of steep, narrow cañons. We find the continuity broken only at such points where important streams issue from the mountains in their course to the low country eastward. This is essentially a typical feature of hog-backs, but the occurrence here is on so grand a scale that the term cannot appropriately be applied. While the western slopes of the third chain are steep, those to the east are more gentle until arrested by the superposition of younger sedimentary bluffs.

Northwest of our district the western subsidiary range forms a portion of the slope of the main chain. Near Muddy Creek the separation

of the two takes place, and the former continues in a southeasterly course. It follows a line slightly diverging from the longitudinal axis of the main range. We find that the continuity has here also been broken, and streams or creeks find their way through the gaps that have been formed.

GEOLOGICAL CHARACTER OF THE RANGE.

Prozoic rocks.

Beginning with the subsidiary range along the western base of the mountains, we find that it is composed of a comparatively coarse-grained, red granite. Structureless, the hills rise to a relative elevation of about 1,000 feet. From a distance they appear as if composed of a large number of bowlders piled on top of one another. Weathering in rounded forms, the hills, in spite of their small size, appear to be quite massive. The granite is composed of orthoclase, quartz, and muscovite. Of these the former has a flesh color, the second is gray. Admixtures of minute particles or crystals of magnetite impart to the rock a bright-red color upon exposure. This is the result of a higher degree of oxidation of the magnetite. After the hills are fairly separated from the western slope of the main range they are bordered on either side by young sedimentary strata. As these show a nearly horizontal arrangement, the granitic hills appear like islands above them. Extending eastward the granites disappear, and schists take their place. So far as could be determined, the latter merely form a covering, hiding the former from sight.

This occurrence of prozoic rocks is one of great interest. Although in close proximity to the Wind River Range, this latter shows no granite of the same character. In our whole district it appears but twice more, and each time it exhibits the same features here observed. The granitic outcrops near the Sweetwater River, south of Saint Mary's Station, and again a portion of those formed by the Granite Hills show the same rock. From this we may argue an existing subterranean connection, one which during the earliest periods of sedimentation was exposed and unbroken. I regard this granite as the oldest rock in the Wind River Mountains, a view which is sustained by an absence of all structure, its relative position to the range, and its relations to the undoubted metamorphic rocks farther east.

Metamorphic rocks.

Upon examination we found that the prozoic granite above described disappeared altogether in the main chain, except northward, where it formed part of its western slope. The highest portions of the Wind River Mountains are composed entirely of metamorphic rocks. Granites mainly, with some schists, build up the main chain. In color, composition, and mode of weathering the granite here differs from that immediately west. It is hard, fine-grained, of white to gray color, and composed of orthoclase, oligoclase, quartz, muscovite, and some phlogopite. Within certain zones, which are not entirely constant however, amphibolite replaces the micas, either partly or entirely. Syenitic granite or syenite is the rock produced by this change. Accumulations of either mica or quartz at some localities change the character of the rocks. We have, altogether, a typical occurrence of metamorphics, one exhibiting many of the variations to which this class of rocks is subject.

Although special examinations were made to determine whether the different mineralogical constitution of the rocks remained constant within

certain zones, no applicable data upon this point could be obtained. It is evident that the processes producing metamorphism must have involved a great many factors of enormous power. Certainly one or more of these factors resulted in extensive stratigraphical disturbances. We find that the granites are flexed and contorted in every possible direction. Within the main chain the stratoid segregation of the granites is not very completely carried out. It may be noticed, however, that the arrangement of constituent minerals indicates the former planes of stratification. This feature is also demonstrated by the breaking of the granite masses. They form sharp, angular bowlders, frequently with two parallel sides. Within the same block of granite often several lithological varieties may be found. Inclosures of micaceous or chloritic schists, exposed as narrow, ramifying, or simple bands, denote the original planes of stratification. Could they be hewn out of the block they would form undulating tablets with parallel sides. As well as on a very small scale, we may note the occurrence of this feature in so extensive a manner that it affects the structure of the chain. Broken and displaced by the violent contortions to which the masses were subjected during and since their metamorphosis, the continuity of the entire system is now no longer intact. It would require the most careful examinations, conducted on a liberal scale, as to time, to elicit evidence bearing upon the former condition of this metamorphic area. I am confident that, to a certain extent, these examinations could be successfully carried out. The establishment of facts that their results would indicate could furnish us with a most accurate account of the earliest history of this region.

On the western slope of the main chain we have ample opportunity to observe the weathering of these rocks. As a rule they are so firmly cementedby the metamorphosing influences that the local predominance of one constituent or the other produces no marked result. Erosive agents attack the granites but very slowly. While that exhibited by the subsidiary range is deeply furrowed, looks old and weather-beaten, the granites of the main chain have a comparatively fresh appearance. Hard and firm, they are, for long distances, very homogeneous. Breaks of the original strata and inclosures of softer rock, provided they are of sufficiently large extent, have been taken advantage of by erosive agents. They probably have first given impulse to the formation of depressions that to-day exist as gulches and cañons. Water and moving ice, with their accompanying bowlders and gravel, both tend to smooth and polish the granites.

As we leave the crest of the mountains and proceed to the eastward, we notice a general change in the character of the rocks. While they have been massive and compact heretofore, they now show more decided stratification, weather in sharp pinnacles, and form steep slopes or perpendicular walls. Upon examination we find that the purely granitic or syenitic character has disappeared to a great extent, and that we have before us either schistose granites or typical schists. It is this zone of schists, essentially, that gives rise to the steep and precipitous eastern slopes of the main chain. The schists may be traced for some distance, but eventually their unity is broken and their place is supplied by other rocks. Taking into consideration the structural stratigraphy of the main chain, we find that the beds dip steeply to the eastward. At some localities the granitic masses are so homogeneous that no attempt at stratification can be observed. It becomes very apparent, however, as soon as we reach the schists. Few metamorphic regions can be found where the structural conditions of rocks remain uniform even for a short

distance. So here, too, we find a large number of extensive displacements. Enormous fragments have been broken from the main mass and have been thrown into regions where they appear, from their relations to surroundings, as total strangers. Some portions have been plicated and overturned, presenting features of structure and texture that are entirely at variance with those of the vicinity.

Eliminating such occurrences, we may, from the standpoint of a stratigraphist, regard the main chain of the Wind River Mountains as a steep, anticlinal range, a portion of the anticlinal fold being obscured. It will be seen that the remaining portions of the range corroborate this view.

Passing over the "belt" of schistoid rocks on the eastern slope of the main chain, we once more enter a granitic area within the foot-hills. Although resembling, to a certain degree, the granites farther west, we here find decided differences. Perhaps the most striking is the well-developed structure. On the higher portions of the foot-hills this is not so noticeable, as their exposed position has necessarily caused serious disturbance of the integrity of the stratoid masses. At such points they are thoroughly broken, partly by virtue of the prominence of original planes of deposition, partly on account of transverse joints. As we descend along the ridges, however, we find the character of this granite well exhibited. Frequently quite considerable areas can be seen where the bare rock is exposed. There we note the more or less clearly defined stratification, which is evident at a glance. We find that the strata of granite retain their easterly dip, which gradually assumes a lower angle (from the horizontal). This even slope becomes more prominent as we approach the area of unchanged sedimentary beds. An interesting occurrence may be observed in this connection. High up in the foot-hills the granite resembles that of the main chain in lithological character. It is generally gray to light brown, contains orthoclase, oligoclase, quartz, and muscovite. Accessory minerals consisting of amphibolite, chlorite, and—rarely—corundum are found there. Near the eastern base of the foot-hills the first sedimentary beds consist of red quartzites. They bear ample evidence of having been metamorphosed. Immediately below these quartzites we find regular, well-defined strata of reddish and red granite. It is coarser grained than high up in the hills, and contains but very little oligoclase. From the appearance of the ridges it is evident that large masses of sedimentaries, once covering them, have been removed. Erosion progressed to such a depth that the hard granites were reached, and these now lie exposed upon the surface. At some localities it seems very difficult, indeed, to determine where the granite ends and the red quartzite begins. The latter frequently extends in tongue-shaped masses up on slopes of the ridges, while they are cut away in the valleys and cañons. At both of these places the junction-line between the two is sometimes very much obscured. Above the quartzites we have unchanged sedimentary beds.

From these observations we are enabled to say, with certainty, that the seat of metamorphosing influences was removed in a direction from the third chain toward the main longitudinal axis of the range. It may further be said that the direction along which these influences exerted their force is determined by lines rectangular to the trend of the third chain and its scattered continuations.

As we follow the foot-hills in their southeasterly course, we reach a point from where they branch off to the eastward. The continuity of the chain is somewhat broken here, but it can readily be traced, more particularly by the aid of the sedimentary beds. In this deflection it remains parallel with the range. If we examine the conditions existing

at the extreme southern end of the Wind River Range, where the transition into the Sweetwater Hills begins, we will find: That the granite of the subsidiary range has disappeared from the surface; that steeply-dipping schists occupy the region where we might expect to find the former; that the granite of the main chain, the schistoid rocks of its eastern slope, and the granites of the higher foot-hills have sunken out of sight; that the granites of the lower foot-hills occupy points of higher elevation than they do farther to the northwest, and that the relations of the quartzite and unchanged sedimentary beds to the latter are not affected. We observe, furthermore, that the character of the schists here exhibited is not identical with that observed in the main chain, and that their thickness is by far greater. From the relative positions of these various groups it follows that the schists in question cover the granite of the subsidiary range. That of the main chain and of the higher portions of the foot-hills has probably pinched out in part and lies buried beneath the younger masses elsewhere found near the base of the hills. In the hills near Miner's Delight this granite shows a dip of about 25° to the eastward and remains conformable with the sedimentary beds superincumbent.

Within the area upon which the schists are exposed, we observe a number of varieties. Micaceous and hornblendic are the two chief varieties, but gneiss and chloritic schists are not wanting. They dip steeply, almost 90°, to the eastward. From the hills south of Camp Stambaugh their strike, and in a measure their dip, can be beautifully observed. Seen from the summit of some point, the harder strata, which have resisted erosion, give the ground a regularly furrowed appearance. This extends frequently for some distance, and may be suddenly broken off. So far as could be observed, the dip of the schists decreased as we proceeded toward its junction with the younger granites. A number of good exposures in small cañons furnish ample information toward the southern end of the metamorphic area.

Reviewing in a few words the result shown by all these occurrences, we have, following a line from below South Pass to Miner's Delight, a sinking of the oldest granites accompanied by the appearance of younger schists, an elimination of the rocks elsewhere composing the central portion of the Wind River Range, and a rise of the youngest granites of the region. It seeems that the enormous bulk of material from which the rocks composing the highest mass of the range was obtained was exhausted near this line. The original products of deposition there accumulated had come to an end, and only those now represented by the younger granites existed at the locality. This condition of affairs permitted the older, or probably even oldest, sedimentary products to rise sufficiently high to reach to the present surface. Their quantity was not sufficiently great to rise to the same elevation that the masses farther northwest reached, or we should to-day be without South Pass. From subsequent statements it will be seen that farther eastward we have an analogous case where still another member of this same group disappears.

An important feature of this older metamorphic area is the existence of metalliferous veins. The mines of South Pass, Atlantic City, and Miner's Delight are located in the old dark-colored schists; all of them contain gold. This distribution explains why as yet no remunerative veins have been found in the metamorphics of the main chains. A number of metalliferous veins have there been observed, but none of them carry the precious metals in quantities greater than mere traces. A number of lodes have been discovered, and some exaggerated reports thereabout are current. So far as our observations extend, the metal contained in

these veins is simply iron (hematite), with a trace of silver. This character alone indicates a difference between the formations containing the veins. Following out the lesson taught by the character of these occurrences, we may conclude that the main chain of the Wind River Range will not be found to contain auriferous lodes. They will be confined almost entirely to the old metamorphic schists.

The total area covered by the metamorphic rocks is quite an extensive one. Beginning near the northwestern corner of our district their border runs along the western base of the Wind River Range near the point where the Sweetwater issues from the mountains; the metamorphics make a curve to the southward, reaching Pacific Springs. From there they turn toward the eastward, and end at the Little Cañon of the Sweetwater. Curving northward, and afterward to the northwest, they remain inside of the third chain, following a course approximately parallel with the trend of the range.

Isolated outcrops occur south of Sheep Mountain. A number of hills are found there, having a general trend south of east, which are composed of granite. It is the same rock which we have heretofore found along the base of the foot-hills. These granitic outcrops disappear, in part, under the younger Tertiary strata to the southward; in part they are covered by the red sandstone we find at the base of the foot-hills.

Either the force which caused the elevation of the Wind River Range had spent itself near this point, or the same class of material which composes the greater portion of the range did not exist here. I am inclined to this latter view. We have, as will be seen subsequently, ample evidence in this region of severe disturbances, but we nowhere find either the schists of the eastern slope or the granites of the main chain. The granites here totally disappear from sight, and are not found again until they crop out in the Sweetwater Mountains. While this granite once more shows itself, the schists of the Camp Stambaugh region do not again appear on the surface. During the discussion of the Sweetwater area we shall have occasion to enter into these features more fully, as we there find the continuation of several important groups.

PALÆOZOIC FORMATIONS.

SILURIAN.

Groups of the Silurian formation have been found, with some interruptions, all along the eastern base of the Rocky Mountains. Usually they are limited to the Potsdam and Calciferous series. In Southern Colorado, strata have been found at Canyon City, Colorado Springs, and farther north, at the eastern base of the Front Range, which belong to these groups. From there north and northwest a number of localities have been observed where they occurred. We find in our district a disconnected series of Silurian strata.

Potsdam Group.

On the eastern base of Wind River Range we observe a hard, red, quartzitic sandstone directly overlying the youngest metamorphic granites. Extending upward on the gently-sloping ridges at the eastern edge of the second chain, these quartzites occupy positions rendering them prominent and of importance in the landscape. Cut away by erosive action they recede eastward in the narrow valleys and cañons, but reach up for various distances on the ridges intervening. Thus a horizontal

projection of their area will be terminated on the west side by a scalloped line. From west of Camp Brown these Potsdam sandstones extend southeastward, lying between the base of the second and the western edge of the third chain. Comparatively massive stratification is shown by the group. Narrow interstrata of sandstone showing a highly argillaceous composition produce changes in the weathering of exposed surfaces. In direct contact with the most recent metamorphic granites described from this region, it is not unfrequently a difficult matter to draw the line of separation between the two. Often the junction may be found exposed, and there we see, in certain instances, that the quartzites and granites blend into each other. Similar cases have been observed elsewhere, particularly in Colorado.*

It is an evident fact that the same influences which have produced the metamorphism of the underlying granites have transformed the original sandstones into the Potsdam quartzites.

So far as could be determined the dip of the sandstones varies from 35° to 42°, its direction being determined by a strike parallel to the trend of the range. About east of Miner's Delight the Potsdam Group is hidden from sight by overlying beds. Again it appears on the Sweetwater, near what has been designated as the "Little Cañon."

The thickness of the entire series may be regarded as varying between 180 and 320 feet. In part, this is due to unequal extension of the metamorphosing influences, in part to local thickening of the beds. In coloring, the sandstones exhibit a number of shades, changing from bright red to a dark, rusty brown. Wherever they have been exposed in comparatively isolated masses they have lost some of the coloring matter and are brownish gray, in rare instances even white.

Organic remains here, as at many other localities where the group is exposed, are limited to a few species. I observed a *Lingula* (probably *L. prima*) in considerable numbers, but in a very poor state of preservation. Within the same beds, in the Black Hills of Dakota, Dr. Hayden found (1857) *Lingula antiqua*, *L. prima*, and *Obolus oppolinus*. (?) Near South Pass, on the Sweetwater, he found (1870) *Obolella nana* in the same beds.

Near Camp Baker, Dana and Grinnell collected some fossils in apparently the same horizon. Although the palæontological evidence collected within this group is meagre at best, it would be sufficient to establish the identity of the series, even were not this made apparent by its relative position.

Calciferous Group.

Usually some representatives of the Calciferous Group may be found in connection with the Potsdam. Dr. Hayden, in speaking of the latter series, regards the Carboniferous strata as resting directly upon the Potsdam. Professor Comstock takes issue with him on this point. He says:† "This, as we shall see, is certainly an error; * * * there are some indications of the thinning out of the Calciferous beds in the neighborhood of South Pass, which would partly justify his opinion." The examinations made by Dr. Hayden upon this point were mainly in the region of South Pass. At that locality the Calciferous beds cannot be recognized. Along the eastern base of the range a number of strata appear that may be referred to this group. Toward the southeast they thin out and entirely disappear before we reach the Little Popo-Agie.

---

* Compare Rep. U. S. Geol. Surv. 1874, p. 211.

† Report upon Reconnaissance of Northwestern Wyoming, 1873. Washington, 1874, p. 109.

It is not an easy matter to make subdivisions in an extensive series of limestone strata unless material aid is afforded by palæontological remains.

Resting directly upon the red quartzites of the Potsdam Group we find a thin series of sharply-bedded strata. They are composed of blue limestones, blue and yellow dolomites, and, locally, of oölitic dolomites. Siliceous inclusions of irregular form appear within these rocks, as well as higher up. About 250 feet may be regarded as the maximum thickness reached within our district. A definite thinning out and eventual disappearance of the beds may be observed to the southeast. We have, in this appearance of the Calciferous Group, evidently the southern edge of what appears farther north as an extensive series.* While the beds in that direction are very considerably amplified, we find but the termination both of horizontal and vertical dimensions of this group in our district.

In stratigraphical relations the Calciferous series of this region is entirely conformable with the underlying Potsdam quartzites. Both dip off from the mountains, and both are exposed along a line following the general trend of the range. It may be observed that the angle of dip decreases very slightly as we approach the lower country to the east. Some fossils were observed within the beds belonging to this group, but they were so poorly preserved that they could not be identified. Professor Comstock mentions *Orthistritonia*, *Dicellocephalus*, and *Theca* (?) as occurring there. As his investigations extended farther northward than mine, his opportunity for collecting palæontological remains was much more favorable.

While the Potsdam sandstones are the result—in that region—of a long, shallow shore deposit, extending in a line approximately parallel with the elevation of archaean rocks, the waters depositing the material which now composes the Calciferous Group approached from the north and northeast, extending but a short distance into our district. It is for this reason that we find, firstly, the increased horizontal and vertical dimensions of the group elsewhere, and, secondly, the direct superposition of the lowest Carboniferous strata upon the Potsdam sandstone within the remaining portions of our district. At the period during which the later Silurian fauna appeared in that section of country, the region where we now find the red quartzites exposed had already attained considerable elevation, thus rendering it impossible that any extensive accumulation of Calciferous beds should take place. No evidence was obtained indicating a direct removal of Calciferous strata prior to the deposition of Carboniferous beds. For this reason the explanation above offered suffices for the occurrences noted in this instance.

Professor Comstock separates a number of strata overlying the last-described beds as the *Niagara Group*. The section which he furnishes is obtained from a region west of Camp Brown. To this group he ascribes a thickness of 150 feet. I have failed to find any decisive evidence that would warrant such a division. Palæontological evidence, as furnished by the Silurian limestones, is so extremely meagre and unsatisfactory that we cannot appropriately apply to the series the same rules for subdivision that elsewhere may be definitely expressed. While examining the eastern slope of the range I observed the same beds which he has designated as Quebec and Niagara, but I am not prepared to admit of any subdivision at those localities. We have red quartzites resting directly upon the granites, and a series of limestones and dolomites

*Compare Dana, Report of Reconnaissance of Yellowstone Park, 1875, Ludlow, Washington, 1876, p. 133.

about 250 feet thick overlying them. Toward the north these latter increase very much in their vertical dimensions. The work of Professor Bradley and others has shown that a continuation of the same Silurian area northward will furnish us with ample material to make the subdivision more complete. Within our district, however, the group is so restricted that this cannot properly be done. I close the Silurian occurrences of this region with the beds of limestone, dolomitic in part, which have been described above. This furnishes for the Silurian strata on the eastern base of Wind River Mountains a maximum thickness of 550 feet. Near Miner's Delight this is reduced to about 260 feet, widening somewhat again farther southeast.

DEVONIAN.

Any positive determination of strata as Devonian meets with considerable difficulty along the main chain of the Rocky Mountains. There is scarcely an applicable change in the lithological character of the rocks composing them as compared to older or younger strata. Besides this, we find it to be a widely perceptible rule that the faunal remains of Devonian and Lower Carboniferous strata show a remarkable affinity of form. Basing our deductions upon evidence of the latter only, we will either generally arrive at no satisfactory results whatever, or we will frequently be misled. In reference to this point the late Professor Meek says:* "They (*the fossils*) belong, without exception, to genera that are common both to the Carboniferous and Devonian, while a smaller portion of the genera is also represented in the Silurian."

Professor Comstock at first referred certain strata occurring above what he considers the Niagara Group to the Devonian, but subsequently retracted this view of the subject.†

So far as my examinations extend, I can see no evidence which would justify the determination as "Devonian" of any of the strata exposed in that section of country. Neither the character of the fossils nor the arrangement of beds, as compared to other regions, speak for any such identification. Remembering the fact that the region we are speaking of is located essentially along the terminal line of the older Palæozoic depositions, we will readily understand why certain groups should either be wanting entirely or should appear in so subordinate a manner as to make their specific recognition an impossibility.

CARBONIFEROUS.

Among the Palæozoic formations found within our district, the Carboniferous occupies the most prominent position. Although closely resembling in certain of its characteristics the same formation as exhibited farther south, we here find some interesting variations. In Colorado three divisions can usually be recognized. They are constant throughout nearly the entire State, and are, individually, well defined. On the western slope of the Wind River Range, and at other localities within our district, we are enabled to separate the entire series into the same number of groups. The term "Subcarboniferous" has been used for the purpose of indicating certain beds below the horizons established by typically Carboniferous fossils. I take occasion to apply it in the present instance for classificatory reasons, but desire to state that the group

* Rep. U. S. Geol. Survey, 1872, p. 432.

† Compare Am. Jour. Sci., vol. vi, 1873, and Rep. Rec. Northwestern Wyoming, 1873, Washington, 1874, p. 112.

shows palæontological affinities to the Devonian in its lowest members. As the above appellation is here used, it implies a slight separation, both lithological and faunal. We have within the region under discussion a succession of strata which can appropriately be separated into two divisions. The older one of these I shall quote as "Subcarboniferous." This term is synonymous, in this instance, with the "Lower Carboniferous" of some other writers, and the analogies will be apparent upon comparing descriptions.

Subcarboniferous.

Dr. Peale characterizes the Subcarboniferous group of Colorado as "mainly massive limestones, grading below into Devonian (?)." This, in a great measure, will express the constitution and relation of the parallel division near the Wind River Mountains. The third chain of the range, which has in previous pages been regarded as analogous in structure to hog-backs, is composed of Carboniferous strata. West of Camp Brown this chain enters our district and continues well defined along the base of the range until it is lost in the scattering hills east of Miner's Delight. If we examine the western bases of the isolated hills composing the chain, we will find there the exposures of Lower Carboniferous strata. They are composed mainly of massive beds of limestone, slightly dolomitic in part. Interstrata of dolomite and some dolomitic shales separate them. Accumulations of arenaceous material within certain strata impart to them the character of calcareous sandstones. Wherever they rest upon members of the calciferous series it becomes a difficult matter to draw the line between the two. It can be accomplished, however, if the latter are followed in a southeasterly direction until, finally, the Lower Carboniferous is found to rest directly on the red Potsdam quartzites.

Conformable with over and underlying beds, this series dips to the northeast. About 38° may be regarded as the dip angle. Locally this is increased somewhat, more particularly near the ends of the hills composing the outlying chain. For some distance upwards along the western slope of the hills the characteristic, heavy beds, either of gray or yellowish color, may be distinguished. The various interstrata are thin, and upon weathering show prominently. North of our district, in the regions of greater Palæozoic development, Dr. Hayden and others have recognized mainly two divisions in the Carboniferous formation. There, as here, the line of separation between the two has been difficult to establish. No satisfactory division can be obtained in the Wind River region by the occurrence of fossils, and I have therefore employed, in a measure, the lithological character to furnish it. We find, upon examination, that the gray and yellow limestones, as well as the included dolomites, disappear some distance above the base of the bluffs. They are covered and succeeded by massive beds of blue and some almost white limestone. At the junction of these two series I place the dividing line. Besides being thus marked, it is indicated by a change in the occurrence of fossils. This change is not so much one of species as one of specimens. In the lower group fossils are found but sparingly, but higher up they occur more abundantly. Regarding the termination of the Lower Carboniferous as existing where it has just been placed, we will have a thickness of 600 to 700 feet for it. This is subject to some variations, dependent upon local widening of certain strata.

Most of the fossils contained in this series are very poorly preserved, in rare instances, only, admitting of more than generic determination.

We observed some *Spirifers*, *Orthis*, *Crinoids*, and *Orthoceras*. In some of the calcareous sandstones indistinct remains of fish-scales were found.

From what has been said of the relative position of the strata composing this group, it will be seen that in its horizontal projection it essentially follows the western base of the third chain. Extending from the northern border of our district, it remains exposed until hidden from sight by the superincumbent Tertiary beds a short distance southeast of Miner's Delight. It again makes its appearance at the Sheep Mountain Group. The recurrence there will be the subject of discussion in subsequent pages of this chapter.

Carboniferous.

Under this head I comprise the middle portions of the formation. The entire series located between the upper limits of the Lower Carboniferous and the beginning of the Permian beds is one of great uniformity. Blue, massive limestones, exhibiting but few variations, compose the entire mass. Near the base of the series, which is located at about the lower third of the high, outlying hills, we find that some of the strata still retain a slightly dolomitic character. This is of no orographic importance, however, as neither in color nor mode of weathering they show any appreciable difference from beds higher up. Ascending towards the summits of the hills we find that the strata become very massive and are composed of blue, rarely whitish, limestone. Some strata may be found where this is crystalline. Numerous fossils are inclosed within these rocks, nearly all of them silicified. This style of petrifaction has resulted very disastrously to the preservation of exterior form. Evidently the process by which the substitution of silica for the original material composing the shell was effected, is one of infiltration. Had the progress of this replacement been a perfectly regular one, *i. e.*, had the removed particles of calcium carbonate been replaced immediately by silica, the result would have been different. Instead of a complete pseudomorph, however, we find but partial ones, rendering the details and often even general form of the fossils very imperfect.

Throughout the limestones of this group we observe large quantities of siliceous concretions. They occur in numerous shapes. Either narrow veins, irregular inclusions, geodes lined with brilliant crystals, or seams filling systems of small fissures, traverse the entire rock. Flint, jasper, chalcedony, hornstone, basanite, and white or yellow quartz, compose these included masses. They may be regarded as typical for this group of the Carboniferous formations. Although they extend downward into the underlying strata, they are not found in the same large quantities, neither are they so persistent in their horizontal and verticle distribution.

There were but few fossils obtained from this group, owing to their mineralogical character. Among those found were *Productus semistriatus*, *Spirifer*, *Orthis*, *Athyris*, *Crinoids*, and near the base *Orthoceras*.

Following the Carboniferous group southeastward from the northern border of our district, we find that it composes the bulk of the outlying hills. Dipping almost uniformly toward the northeast, the angle of inclination is about 36° to 40°. Toward and on the western slopes of the hills, we find it somewhat larger than farther eastward. As we proceed along the eastern slope of third chain, we find it cut transversely by the various streams of the Wind River drainage. First, we cross the North Fork, Baldwin's Creek, and some smaller tributaries. These pass through open gaps which break the continuity of the hills. Maintaining

a very even altitude, we suddenly come across a deep, narrow gulf in the rocks. Through this flows the Little Popo-Agie. The cañon is not a straight rent across the strata, but runs in a zigzag line. This feature is one endowing it with additional beauty. Regarding its formation it may be said that it can scarcely be considered as the result of erosion, but rather as that of seismic action. It is highly probable that other passages across this chain owe their present location to the formation of fissures which must be ascribed to the same cause. In case these extended but a short distance downward, fluviatile erosion would tend to widen them, until, eventually, a broad "gate" has been produced. Continuing along the hills in the same direction as above, we find that Twin Creek is forced to make a considerable detour along their western base before it finds apoint where it can cross. Shortly after that has been reached we see Tertiary strata covering the Carboniferous and shutting their southeasterly continuation out of sight.

Along the same line of travel we find two further features which change gradually as we advance southward. The first of these is the decline of dip-angle. While we have, west of Camp Brown, a dip of 36° to 40°, we find that east of Miner's Delight this has decreased to about 30° to 35°. As a rule, the diminution of the angle occurs at a very regular ratio. Besides this fact, we notice a change in the relative position of the Carboniferous strata and those belonging to younger groups. West of Brown the Mesozoic beds reach upward a considerable distance upon the eastern slopes of the hills. Near Miner's Delight, however, the entire slope exposes Carboniferous beds. Although the ratio of recession to the eastward is not so uniform as that of the decreasing dip, it is sufficiently constant to be regarded as a striking characteristic. On the surfaces of limestones thus exposed to atmospheric action, we observe peculiar results produced by erosion. The impregnation of siliceous matter is an irregular one, and its distribution is indicated by the corrugated surfaces produced by erosion. Numerous white fossils not unfrequently cause the formation of small columnar products of erosion resembling stylolites. The exposure of Carboniferous rocks, so far as in direct connection with the Wind River Range, ends a short distance southeast of Miner's Delight. I have considered it best to treat first of those portions most intimately related to the range, before describing the isolated occurrences farther east. These latter owe their present position to different causes from the former, and are geologically separated therefrom, although geognostically and lithologically identical.

So far as our observations extend, no strata have been found in connection with the Carboniferous formation that can be proved to be Permian. Immediately resting upon the limestones we find a series of shales, sandstones, and some dolomitic limestones. Although I am not prepared to furnish any palæontological evidence of its age, I am inclined to separate the group at least provisionally. It will be spoken of in subsequent pages as Permian. In case future investigations prove that it should not be regarded as Permian, it must be referred to the base of the Mesozoic formations.

PALÆOZOIC FORMATIONS EAST OF THE WIND RIVER RANGE.

Subcarboniferous.

East of the Wind River Range, Carboniferous rocks have been brought to the surface by virtue of serious, more or less extended, stratigraphical disturbances. Examining Sheep Mountain. we find that its summit is

composed of white and light yellow quartzitic rocks. Descending either east or west, we observe that these are overlaid, first, by magnesian limestones, unchanged, and then by massive beds of blue limestone. We have, in this instance, a protrusion of Subcarboniferous rocks along a definite anticlinal axis. Near the central line of upheaval, we find them thoroughly metamorphosed. Toward the north they are soon hidden from sight under the heavy limestone strata. Following the outcrop southward, we find that the axis of the fold turns in a southwesterly direction, exposing the older series on high points. Occasionally a cañon is cut down deeply through the Carboniferous limestones, and there again we see the Subcarboniferous strata. The white and yellow quartzites of the region are evidently the metamorphosed calcareous sandstones which have been mentioned in previous pages. Approaching the northern edge of the Sweetwater group while following the anticlinal axis, we find that not only Subcarboniferous beds lie exposed, but that Potsdam sandstone and granite make their appearance. A few strata above the former might be referred to the Calciferous series, but they are very insignificant. Necessarily the area of these older rocks is a restricted one, as the dips on either side of the axis of upheaval are very steep. Younger groups, leaning directly up against the former, render their outcrops quite narrow.

Carboniferous.

Conformable in every respect with the Subcarboniferous group are the limestones belonging to this series. In their general arrangement, as well as in their detail features, they show no variation from the character as exhibited by the same group farther west. After they have disappeared from the surface for some distance, we first find them again forming the slopes of Sheep Mountain. Here, as elsewhere, the thickness of these massive limestones amounts to about 2,000 to 2,200 feet. Near the northern base of the mountain they sink out of sight, but continue for some distance on the southern side. Forming there the narrow, walled cañon of Beaver Creek, they extend south and southwest toward the northern edge of the Sweetwater group. In their course they follow the anticlinal axis of this region. Owing to a diminishing dip, both toward the east and west, they are exposed over a considerable area. So far as I could determine, no unbroken surface-connection exists between these Carboniferous beds and those of the third chain, so long as both remain within the area of Wind River drainage.

On the south side of Beaver Creek a very interesting series of springs was noticed in the Carboniferous limestones. A gentle slope leads northward toward the stream from the higher hills along the anticlinal axis. In the limestones of this slope we observe a vertical opening. It has the form of an ellipse, is about 200 feet long, 150 wide, and 120 deep. Some process, whereby a cave of corresponding proportions had been excavated, had rendered the roof-rock unsafe until it fell down. The walls of the "hole" are perpendicular, and show the influence of chemical action. A short distance downward from this opening there is a hot sulphur spring. It bubbles up out of the rocks through a deposit of fine sand and some gravel, emitting large quantities of sulphuretted hydrogen gas. The temperature of the water is 96° F. A few hundred yards below we find another spring, containing the same kind of water, but ice-cold. On the bottom of the hot spring the pebbles, when taken from it, show a thin gold-colored coating. This is very uniformly spread over them, is bright, and is composed of pyrrhotite, nearly simple sulphide of iron.

We notice, occasionally, in this region, as well as farther west, that some of the Carboniferous strata contain impregnations of pyrite. A decomposition of this mineral, together with such changes to which the adjacent rocks would necessarily be subjected, will generate a considerable amount of heat. I consider it probable that the former cave, which occurs near the springs, at one time contained a reservoir which supplied the latter. It is possible that at the present time another one exists, still intact, therefore not revealing its presence. This view receives some support from the fact that the nearer spring is the hot one, while the other, though showing the same composition and passing through the same kind of rocks, is cold.

A section given with the succeeding pages will easily render clear what has been said with reference to the stratigraphical features of the preceding groups. They present a highly interesting field for study, one to which an entire season could be far more appropriately devoted than a few weeks.

Permian Group.

Wherever the Permian group has been observed in the West, its definition as such has been a matter of more or less difficulty. A want of characteristic fossils and the sporadic appearance of the series has had to be contended with. So far as any identifications have been made which are entitled to consideration, we find that Permian strata occur in Kansas, Colorado, and the Northern Territories. Meek and Hayden have obtained fossils from the beds, and regard the determination of the beds containing them as established. It may be regarded as a rule that the group comprises mainly yellow and red sandstones and shales with some dolomites. In case these exhibit but a slight thickness, they may frequently be overlooked and added to the massive red beds generally overlying them.

Descending the eastern Carboniferous slope of Twin Peak, we reach a low valley trending about northwest to southeast. We find, upon examination, that a portion of the slope is composed mainly of reddish and yellow sandstones, interstratified with shales. Within the shales we see thin banks of hard, crystalline dolomites, and higher up there are thin banks of gypsum. The summit of each little ridge is formed by a hard sandstone, sometimes quartzitic. Atmospheric action has bleached some of the rocks, and they show pink, light yellow, and even white colors. Taking this series of strata, which is closed by a massive bed of white to light yellow sandstone, as a whole, we find that its main bulk is made up of sandstones. Generally these are thinly stratified, containing narrow beds of yellow, pink, and gray shales between them. The group rests directly upon the hard blue Carboniferous limestones, and is covered by the red beds of Mesozoic age. Estimating the thickness of the group near this locality, we may regard it as about 250 feet. Within these limits are confined the strata which I refer to the Permian. No fossils were found within them, except a few indistinct remains of plants. Dr. Hayden has mentioned, in speaking of the Permian of Kansas, that there the upper two or three hundred feet of the group are probably "on a parallel with the Permian of Europe." In case typical Carboniferous fossils extended upward into this series, we would probably have found them, and I am inclined to think, therefore, that they are wanting. Probably only a very limited flora, with perhaps a few invertebrates, existed at this region, and but a small number of the specimens were preserved.

Following this outcrop of Permian to the southward we find that it

disappears under the Tertiary beds of the Sweetwater Group. Toward the north it can be traced between the eastern end of the Carboniferous limestones and the western edge of the Mesozoic red beds. Similar in lithological constitution, it closely follows the outlines produced by erosion in the latter. Subjected to the same effects, these two groups show a similarity of weathering and of type of removal that renders the Permian liable at many places to be overlooked. Northward a thinning out of its strata may be observed; but it continues unbrokenly through our district to the forty-third parallel. At such points where the Carboniferous strata have been brought to the surface we observe the Permian strata in the same relative position to them as they are on Twin Creek. As a rule they have permitted the formation of depressions running parallel with the strike of the strata. In order to make clear the stratigraphical arrangement of Palæozoic strata along a line from the Wind River Mountains to Sheep Mountain, a section is here introduced. It will explain more readily than can be done by words the relative positions of the groups that have been treated of above.

The annexed section (Section I) runs from the Wind River Range to Sheep Mountain in a direction nearly east. In the western portion of the section the arrangement of prepalæozoic rocks is represented. Upon the prozoic granite (*a*) rest the oldest metamorphic schists (*b*). These contain the metalliferous veins, which are indicated. Above the schists we find the granites (*c*) of the main chain. The schists forming the steep eastern slope (*bb*) are given. Metamorphic granite (*d*) forms the chain of foot-hills. Descending with this we reach the Potsdam sandstone (*e*) directly overlying it. A pinching out of the calciferous series (*f*) has been represented by the two converging lines. Above this we find the series of Subcarboniferous strata (*g*) occupying the western base of the outlying third chain. Massive beds of Carboniferous blue limestones (*h*) make up the main portions of the hill and slope eastward towards the younger sedimentary region. At the eastern edge of the exposure of this group we find the Permian strata (*i*). Above them the Red Beds (*k*). Thus far the dip has been a steady easterly one, its angles being indicated on the drawing.

By following the line showing the upper termination of Permian beds (*i*) we will find that the easterly dip gradually diminishes, farther on is entirely obliterated, and then turns into a westerly one. We have, then, the formation of a synclinal fold within this group. On the line of our section the beds are broken off and no connection exists at that point with those farther east. Tracing in a similar manner the flexures of the massive blue limestone (*h*), we find that the same conditions exist here. When we reach the Subcarboniferous strata (*g*), we are enabled to form the connection to the east. In that direction a sharp anticlinal axis succeeds the synclinal fold, carrying the strata up to considerable elevation. The culmination of the latter is reached on the summit of Sheep Mountain. From there the beds fall off toward both west and east. On the latter side we find the counterpart of what was seen from the base of the third chain toward the east. Superimposed upon the Permian are a number of Mesozoic formations, which will be considered further on. Throughout this entire section the various beds show a remarkable uniformity of thickness and lithological character. They are entirely conformable and show no disturbances of continuity. Viewing the elevation of Sheep Mountain, we see that thereby an S-shaped flexure of a considerable thickness of strata has been produced. From evidence obtained in the vicinity, we are enabled to say that the Potsdam sandstones are probare probably to be found directly underlying the Subcarboniferous group at Sheep Mountain.

REVIEW OF THE PALÆOZOIC GROUPS DIRECTLY EAST OF THE WIND RIVER RANGE.

Although the series of palæozoic formations east of the range is incomplete, it is rendered very interesting by the regular superposition of its members, and by the uniformity with which the different groups participate in the effects produced by dynamical disturbances. A table, indicating the succession of strata, is here produced, which may facilitate the comparison of this region with others:

Permian group:

Red and yellow sandstones and shales near base. Thin banks of dolomite in the shales. Yellow sandstones, partly quartzitic and gray, yellow, and pink shales higher up. Sandstones of lighter shades and some gypsum near top. Thinning out toward the north.
Thickness .... 250 feet.

Carboniferous group:

Massive beds of blue, partly crystalline limestones. Near base magnesian limestones interstratified with the others. Concretions, nodules, and small veins of several varieties of quartz traversing the entire mass. Fossils (silicified): *Productus*, *Orthis*, *Crinoids*, *Orthoceras*, *Spirifer*, *Spirigera*, and others.
Thickness .... 2,000 to 2,200 feet.

Subcarboniferous group:

Dolomites and dolomitic limestones near base. Calcareous sandstones and some yellow and brownish shales interstratified. General color of the rocks yellow and gray. Some of the strata blue. Concretions of quartz not so frequent as in the preceding group. Fossils (mostly silicified): *Spirifer*, *Orthis*, *Crinoids*, *Corals*, *Orthoceras*, *Productus*, *Chonetes*, *Spiriferina*, and others.
Thickness .... 600 to 700 feet

Calciferous group:

Blue and whitish limestones and dolomites. Oolitic in part. Interstratified with some thinly-banded shales. Fossils: *Orthistritonia*, *Dicellocephalus*, *Theca* (?), *Corals*, and others. (Gradually pinching out to the southward.)
Thickness .... 220–280 feet.

Potsdam group:

Massive and thin beds of quartzite. Color varies from bright red to deep rusty brown. Narrow interstrata of dark brown metamorphosed shales. Rests directly on the granites. Junction-line often obscured on account of metamorphism. Fossils: *Lingula*, *Obolus*, *Obolella*. Thickness .... 280 to 320 feet.

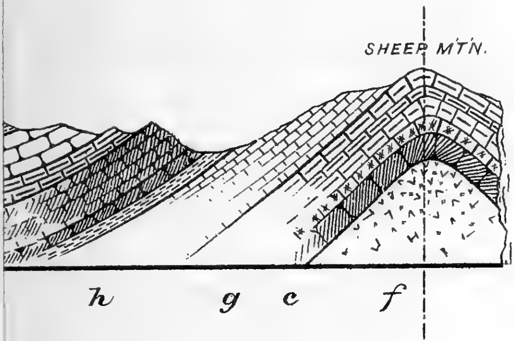
Total thickness of palæozoic formations east of Wind River Range .. 3,350 to 3,750 feet.

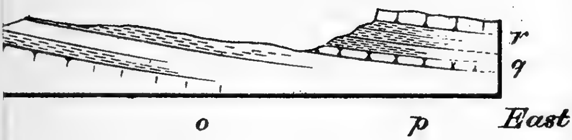
MESOZOIC FORMATIONS.

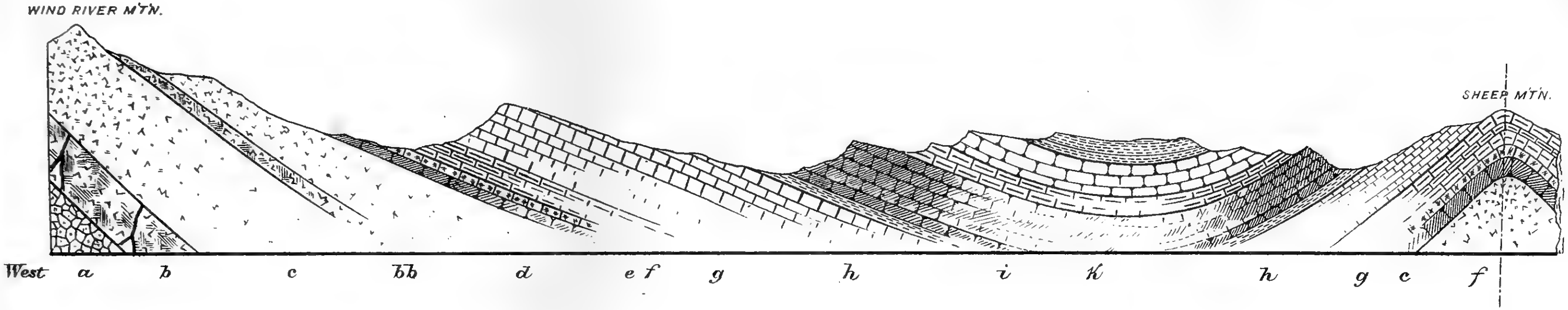
TRIAS.

In Colorado and at other localities we are accustomed to regard the extensive series of "Red Beds" as Triassic. Thus far no palæontological evidence has been adduced in direct support of this view. Examining the lithological character of the series, we find that it closely corresponds with that exhibited by the *Keuper* of the European trias. This latter, similar to our Red Beds, is totally devoid of fossils through about five-sixths of its vertical dimension. As we cannot, however, utilize such similarities for the purposes of establishing identity of formation, we are forced to regard the definite geological position of the Red Beds as unsettled. With this proviso, we shall speak of "Triassic" strata in this report. Subsequent investigations may produce material which will confirm the views provisionally held, or they may radically change them. A large proportion of the fossils that might be expected to occur in the Red Beds, will probably prove, if found, either to offer but little information or to simply afford ample material for discussion as to their correct interpretation.

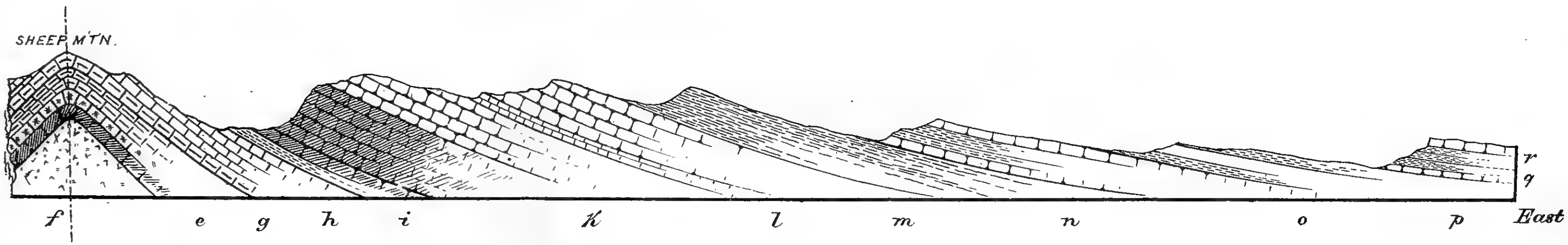
Plate I.







Section 1.



Section 2.

F. D. O.

Within our district the Triassic beds have reached a good development and are exposed very frequently. One of the best known occurrences east of the Wind River Range is that of Red Cañon. If we stand on Twin Peak and look towards the northeast, we will have before us a gradual slope down to the narrow valley of Deep Creek. Rising immediately upon the eastern bank of this small stream we see a steep red wall, continuing for the distance of several miles. The remarkable brilliancy of color renders it a very striking feature of the landscape. An examination of this wall will reveal the fact that it is composed almost entirely of bright red shales and sandstones. Near the base of the series we find red sandstones, highly argillaceous and rather thinly bedded. A little higher up the strata grow thicker and somewhat coarser. They are separated from each other by thin layers of very fine-grained shale. Thus far we have seen about the lower third of the group. Above that thick beds of red shale set in, weathering in characteristic forms. Numerous vertical seams aid the progress of erosion. Near the top of these shales we find thin beds of sandstone, more or less coarse grained, usually red, but sometimes pink and white. Throughout the shales we meet with narrow "ledges" composed of very compact gray and yellow dolomite. Small cavities and seams in them are lined by crystals of the same mineral. Above the shales and thinly bedded sandstones, we again observe massive strata of the latter. Shales close the group. Both near the base and the top, isolated layers of pink and white sandstones may be noticed. As a rule, we may accept two horizons for coarse-grained sandstones, although they are essentially a local product. Near the base, and again in the upper third of the series, they are found. The thickness of the Triassic beds at this locality may be regarded as about 800 feet.

In this region, as well as elsewhere within our district, we find the Red Beds directly overlying the Permian strata, and covered by Jurassic limestones. From the section previously given, it will be seen that the Triassic beds (*k*) are perfectly conformable with both under and overlying groups. Following the outcrop southward from Red Cañon, we find that the red sandstones and shales retain a prominent position until closely approaching the Sweetwater group. There the southwesterly direction of the anticlinal axis causes a preponderance of palæozoic rocks, the greater portion of the younger groups disappears, and the Red Beds are crowded into a narrow space. Finally they disappear under the Tertiary strata, not again to be exposed until many miles farther to the eastward. North of Red Cañon the Triassic strata first make a turn which brings them high up on the eastern slope of the third chain. Receding again they form a series of bluffs along the base of this chain until they pass beyond the limits of our district. So far as the out-crops have been described the strata have a general dip east and northeast, amounting to 32° to 36°. At the highest point reached by them this angle is somewhat increased.

We find that along this line of exposure the Triassic strata presents but a small area. Rapidly removed by erosion on the west side, they are covered by younger formations a short distance eastward. Reverting again to Section I, it will be seen that the Red Beds form prominent bluffs on either side of Sheep Mountain. On the east side they present a steep, quadricircular wall similar to that on Deep Creek. From there southward the bluff-line follows the strike of the Carboniferous limestones, until finally both are lost under the beds of the Sweetwater Group. North of Sheep Mountain we find different conditions, however. A thickening of the entire series is noticeable, which reaches over 1,000 feet. Following down Twin Creek to its junction with the Little Popo-Agie,

we find ourselves very nearly on a line with the anticlinal axis which is marked by such prominent results farther south. The Carboniferous beds have sunk out of sight with the exception of those belonging to the Permian group. Near the junction of Cottonwood with Twin Creek they too disappear. Approaching the Little Popo-Agie we find ourselves once more standing upon Permian strata, while Triassic beds flank Twin Creek on either side. Here, evidently, the force which produced the anticlinal fold asserted itself with great violence. Although the Carboniferous limestones do not again appear, the red beds occupy prominent positions on the high bluffs they form near the junction of the two streams. At this locality the amplification of Triassic strata can be well observed. Near their base thick beds of gypsum set in, measuring sometimes 4 and 5 feet. Gypsum, when stratified, is essentially a local deposit, and we therefore find the beds thinning out rapidly in every direction. At the junction of Twin Creek and the Little Popo-Agie the axis of the anticlinal fold makes a turn to the northeast, and is soon lost entirely. On the Big Popo-Agie it appears again, exposing Triassic beds to view. In subsequent papers this interesting stratigraphical phenomenon will be discussed more connectedly.

About two miles below the entrance of Twin Creek into the Little Popo-Agie we find a very fine petroleum spring. It is located on the south side of the last-named stream, issuing from the base of a small bluff there. During the hot season the oil appears to flow for some distance. It has saturated the sand and gravel in the valley, in some instances firmly cementing it. Evidently the spring has been active for a long period of time, as we observe the coagulated oil on the northern side of the stream. This at the present time is shifting its course in that direction; consequently the oil at present found there must have been deposited a very long time ago. For some distance the smell of petroleum indicates the presence of the spring. Its location is convenient and the oil of sufficiently good quality eventually to prove valuable. So far as my examination extended, it appeared to me that the petroleum must collect from the various deposits of shale in that region, thus rendering its point of outflow one rather determined by accident than by an extraordinarily great impregnation of the rocks found in its immediate vicinity.

JURA.

Generally the strata of variegated shales and marls, associated with some limestones which are found superincumbent upon the red beds, have been regarded as Jurassic. In Colorado and other localities south of the forty-second parallel, fossils have been obtained which render this determination justifiable. Within the Northern Territories Dr. Hayden and others have found fossils which tend to show that the faunal development of the Jura there more closely coincides with that of Europe than farther south. Several species have been collected which belong to European genera and are scarcely specifically separable.

East of the Wind River Range we observe a number of exposures belonging to this formation. Resting directly upon the uppermost red shales of the Triassic strata, we find a narrow band of dark, calcareous shales. These are covered by several prominent banks of dark-blue and gray limestone. For some distance upward follows a succession of shales and limestones. Isolated interstrata of light yellow or white sandstones appear above this in some yellow marls. Higher up, yellow, pink, greenish, and white marls and shales close the formation. A thickening of the strata may be observed as we approach Sheep Mountain. For the entire Jurassic series, so far as it enters into consideration in this chapter, we may accept a thickness of 200 to 220 feet.

In the lower, heavy banks of dark limestone as well as in the higher ones alternating with shale, we find innumerable fossils. Though the most diligent search was made at a number of localities, we could find but very few species. Dr. Hayden in 1857 obtained a good series in the Black Hills. During 1872, additional collections were made by the members of his survey in the Northern Territories. From these it appears that the conditions requisite for sustaining a more varied fauna were favorable in those regions as compared to the one at present under consideration. We found large numbers of a *Pecten* (*Camptonectes*) closely resembling *P. glaber* of the European lower Lias. Two species of *Belemnites*, resembling *B. brevis* and *B. acutus*, were associated with the former, and very abundant. *Gryphæa*, related to *G. arcuata*, but smaller, occurred sparingly. Comstock, farther north, obtained *Lingula*, *Rhynchonella*, and *Modiola*. Although the fossils found are not what might be expected or hoped for, they are sufficiently characteristic to characterize the age of the formation—if taken in conjunction with other points—beyond doubt. Although we found Jurassic exposures many miles apart, the arrangement and mode of occurrence of the fossils did not vary.

In its surface appearances the Jurassic series closely follows the Red Beds. Wherever the latter are exposed, there we find the former. Taking part in the various plications and flexures to which the older series is exposed, we always find the characteristic dark limestones and light-colored marls associated with it. Toward the east a slight increase of thickness may be observed, but so far as the strata were exposed within our district it is unimportant.

Besides the regions which have heretofore been mentioned as showing outcrops of Mesozoic formations, there is still another within the area of Wind River drainage. This is located along the edge of the Sweetwater Plateau, about north of the western terminus of the Granite Hills. There we find an anticlinal fold which has produced very marked effect. The Palæzoic rocks have been raised to considerable elevation, and now are seen as hills on the plateau. A little north of the edge of the latter the upheaval terminates, and there we find the Mesozoic strata resting on the Carboniferous, in a partiversal arrangement of dip. As this is a steep one, the beds soon disappear under younger ones, and the former continuity of the Cretaceous beds is reëstablished. In the Sweetwater Hills we find the southeastern extension of both Trias and Jura, occurring there in the same relative positions as directly east of the Wind River Mountains.

A section (Section II) extending from Sheep Mountain along Beaver Creek down stream as far as our work carried us, will represent the eastern slope of the great anticlinal fold. The lettering is the same as on Section I, new designations having been added for those groups not above included. We find in this section a decided amplification of the Triassic group (*k*). Above the bright-red shales we observe an extensive series of light red, and yellow, and some white sandstones. While the lower mass remains tolerably constant in its vertical dimension, this addition increases the total thickness about 300 to 400 feet. Above the variegated sandstones and shales of this upper group we find the Jurassic limestones and marls (*i*) directly overlying. From the section will be seen the gradual decrease of dip as we proceed northeastward. This line of sections carries us beyond a point where the effect of the upheaval near the Sweetwater Plateau could be felt. Resting on the Jurassic beds we observe the three groups of the Cretaceous formation. They are conformable throughout with older rocks, and tend to assume horizontal stratification as they pass into the low country nearer the main drainage.

By supplementing Section I with Section II a view of the entire series of conformable sedimentary strata may be obtained.

CRETACEOUS.

In discussing the Cretaceous groups of this region, I shall make use of the same nomenclature that has generally been applied to the same series in Colorado. The original five numbers into which this formation was separated are reduced to three. No. 1 remains intact and is designated as the Dakota Group; Nos. 2 and 3 are comprised under the name of Colorado Group, and Nos. 4 and 5 form the Fox Hills Group. This division is one which can readily be carried out in the field, and it expresses the most natural classification of the entire group at many localities. Cretaceous strata occupy a prominent area on the Wind River drainage. Thoroughly regular in their arrangement, except where they take part in the disturbances which have so seriously affected older beds, they reach far eastward into the lower country. Showing a smaller vertical development than farther to the south, the individuality of the groups is nevertheless preserved. Not only is it apparent in the successive arrangement of strata, but many of the detail features, such as produced by weathering, are strikingly similar. A deplorable want of good fossils is felt throughout the entire formation. Fortunately this interferes but little with the identification of the groups, as they are sufficiently characteristic to be easily recognized.

Dakota Group.

Resting directly upon the upper light shales and marls of the Jurassic series we find a succession of yellow and brown shales, interstratified with sandstones of the same color. In these shales, above some of the thin beds of sandstone, we find slight indications of coal. The seams are but halt an inch in thickness, and the coal is of that variety called jet coal. Higher up the sandstones predominate, separated by thin layers of homogeneous, dark shales. Near the top of the group we once more find a heavy bed of shale, which is covered by massive white, yellow, and brown sandstones. A small thickness of arenaceous shales closes the group. This is the general section of the Dakota as exposed west of the anticlinal axis. In some of the upper sandstones indistinct remains of plants were observed, and in the higher shales occurs a *Gryphæa.* For the total series we can accept a thickness of about 400 feet.

In Colorado the Dakota Group usually occupies a prominent position, but here this is not the case. Forming a low, long-continued ridge, the members of this series trend about north and south on the plateau-like elevation between Sheep Mountain and the base of the third chain. To the southward the group pinches out horizontally, owing to the change in the direction of the anticlinal axis. Following it north, we see it in its normal position accompanying the Jurassic beds. Within the areas of vertical distur bance the Dakota, overlaid by Colorado shales, takes part in all the flexures and plications. In consequence of this fact, the horizontal projection of the series assumes a curious shape. Between the anticlinal axis and the outlying hills we find two diverging lines of exposure, trending northward. After crossing the little Popo-Agie, the one runs upward toward the hills; the other takes part in the westerly dip of strata near the mouth of Twin Creek and subsequently joins the first. Another line of the outcrop occurs parallel to the anticlinal axis, and east of it. From there the Dakota beds dip under the younger groups and are lost, until once more appearing at the terminus of the anticlinal fold near Sweetwater Plateau. A glance at the two sections above

furnished will indicate the stratigraphical conditions of the Dakota Group (*m*). The easterly dip toward Sheep Mountain amounts to 12° to 15°, gradually diminishing. Before long we reach a point where the dip is zero, and after that find it reversed. Near the mountain it increases to about 40° westward. On the eastern side it is again gentle, approaching the horizontal as we enter the lower country. In this region a slight increase of the total thickness of the group may be noticed.

Colorado Group.

Directly overlying the upper arenaceous shales of the Dakota Group we find an extensive series of dark gray, slightly calcareous shales. They are thinly laminated, easily eroded, and become light gray or white upon exposure. Covering the highest portions of the region lying between Sheep Mountain and the base of the third chain, they present comparatively steep bluffs parallel to their strike, and rounded surfaces along their dip. A few banks of argillaceous limestone may be found within them. The entire group is a very characteristic one, readily recognized. Its thickness in our district amounts to about 600 feet. Within the upper third we observe that the shales become somewhat more arenaceous than lower down. Evidently this is a deposit which accumulated in very deep water. Unfortunately no fossils were found except a few fragments of *Ostrea*, resembling *congesta* and *Inoceramus*. The position of these shales (*n*) may be seen from Sections I and II. As the youngest member shown in the first section they appear at an elevated point. From there southward they soon end. Northward they follow the Dakota Group, taking part in the various disturbances of the region.

As these grow less prominent and shift toward the northeast, the area covered by Colorado shales expands somewhat. Near Camp Brown, about 6 miles distant, we find a cold sulphur spring, which seems to take its rise in these shales. In this connection may be mentioned the fact that the Colorado shales must be regarded as a very prolific source for alkaline compounds of a highly soluble nature. Within the shales we frequently notice small inclusions of pyrite. Upon decomposition of both this and the shales various salts are formed. When the two are in close proximity we obtain sulphates, otherwise mainly carbonates and some chlorides.

East of the anticlinal elevation the Colorado shales gradually diminish their dip and are finally covered by the succeeding Cretaceous group. They form barren bluffs, steep, usually, on the side where the edges of the strata are exposed; less so along the dip. Bunch-grass, piñons, cedars, and sage-brush comprise the main portion of the vegetation on such bluffs in the regions of low elevation. Fluviatile erosion attacks the shales very rapidly and often carves them into very beautiful miniature ranges, ridges, and valleys.

Fox Hills Group.

In Section I the Fox Hills Group no longer appears. Some distance north of the Little Popo-Agie it sets in, however. Resting upon the gray shales of the preceding group we find brown and yellow shales interstratified with thin beds of sandstone. Some of the shales are very dark and carbonaceous. In the lower portions of the Fox Hills I did not find any properly developed coal-seams. Above this alternating series we met with a considerable thickness of yellow and brown shales. As a rule they are arenaceous, but some of them seem quite free from sand. Small particles of mica occur throughout. Higher up, sandstones set in again, containing, together with thin seams of shales, small deposits of coal. None that I have seen were workable, but I am informed that they are

found of sufficient thickness near the Big Popo-Agie. The upper termination of this group is formed by thinly bedded, micaceous and argillaceous sandstones covered by a thick stratum of the same material. We may regard about 500 feet as the total thickness of this group. Fossils are very scarce, consisting in *Inoceramus* and some poorly preserved plants, so far as we could determine.

Beginning north of the Little Popo-Agie the Fox Hills series can be found to extend northward in a broad band, reaching beyond Camp Brown. It is but slightly affected by the anticlinal upheaval, although its connection eastward is thereby broken. East of Sheep Mountain the group sets in after we have reached the typical bluff country. As indicated in Section II, it dips gently toward the northeast (*o*), gradually assuming a horizontal position. After forming a prominent row of bluffs and several smaller ones, it is hidden beneath younger Post-cretaceous and Tertiary strata.

About 2 miles west of Camp Brown we find a very interesting hot spring, rising in the beds of this group. It is known as the *Hot Sulphur Spring*. Within an elliptic basin, 315 feet long and 250 feet wide, the bright green and blue water is contained. A constant bubbling up of carbonic-acid gas gives it the appearance of boiling. So far as determined, the mineral constituents held in solution by the water are iron, lime, magnesia, soda, and potash. They seem to be contained in the form of sulphates, carbonates, and chlorides. For the bather the water is very warm, and a stay of only a few minutes will suffice to satisfy all desire for a warm bath. From a report furnished by Dr. T. G. Maghee, U. S. A., post-surgeon at Camp Brown, to Dr. Heizmann, U. S. A., I extract the subjoined tables of temperatures.*

Date.	Daily mean, in degrees Fahrenheit.	Temperature of the hot springs, in degrees Fahrenheit.	
		At the shore.	In the centre.
1874.			
March 18	16.00	106.8	109.0
19	13.33	104.0	106.0
20	24.33	107.0	108.8
21	18.00	107.8	109.0
22	24.33	106.4	109.4
23	29.66	107.2	109.8
24	32.00	106.4	108.9
25	35.33	106.0	107.2
26	31.66	107.6	108.1
27	36.33	109.9	110.1
28	27.33	103.6	106.0
29	27.33	106.2	109.4
30	25.33	106.0	107.5
31	23.33	107.1	109.0
April 1	30.00	108.6	110.4
2	36.33	107.2	109.4
3	35.66	107.2	109.1
4	33.66	104.2	106.2
5	29.33	105.4	108.0
6	24.00	108.8	109.9
7	33.33	108.4	110.1
8	38.66	106.9	108.5
9	40.33	108.4	110.0
10	44.33	109.1	110.3
11	45.66	107.1	109.2
12	43.33	101.1	102.4
13	38.00	97.2	99.5
14	34.66	104.6	106.8
15	30.00	105.0	107.5
16	32.33	105.1	106.1
17	28.00	107.6	109.2

* Rep. Rec. Northwestern Wyoming, Capt. Jones, 1873. Washington, 1874, p. 187.

From this table it will be seen that the daily mean temperature affects that of the water but slightly in the centre of the spring. Near the shore so many different factors enter into consideration which may tend to produce a variation of a few degrees, that the true index must be taken from elsewhere.

Regarding the source of heat which supplies the warmth of the water, I consider it due to chemical changes going on within the strata through which the moisture finds its way. As hot water is a more effective solvent than cold, the channels by which the spring obtains its supply will gradually increase in size. From this it may be inferred, provided the chemical action continues in a proportionate ratio, that the waters of the spring may still grow warmer in the course of time.

A petroleum spring also occurs near Camp Brown, originating, probably, in the same rocks. We observe the globules of oil rising in water and eventually accumulating near the banks. Here a somewhat extensive deposit of hardened black oil is formed. It burns very readily, and appears to be nearly pure.

REVIEW OF THE MESOZOIC GROUPS EAST OF THE WIND RIVER RANGE.

All of the Mesozoic Groups in this region may be regarded as typical to a certain extent. Several of them show a considerable amplification to the eastward, but otherwise remain tolerably constant. In their relations to each other they are constant throughout.

Fox Hills Group:

Sandstones and arenaceous shales near base. Following are heavy beds of shale. Indications of coal near bottom and top. Shales and upper sandstones are more or less micaceous. Thinly bedded sandstones with some shales near top. Massive yellow sandstones close the group. Fossils: *Inoceramus* and indistinct plants.

Thickness .... 500 feet.

Colorado Group:

Dark gray shales, finely laminated. Slightly calcareous near base. Upon exposure the shales turn light gray and white. In the upper half thin bank of argillaceous limestones. Near the top the shales becomes lightly arenaceous. Fossils: *Inoceramus, Ostrea congesta.*

Thickness .... 600 feet.

Dakota Group:

Yellow and brown shales near base, containing thin strata of sandstones. Some carbonaceous shales a little higher up. In the middle sandstones, separated by thin bands of dark shale. Massive yellow, white, and brown sandstones near top. Dark yellow and brown shales close the group. Fossils: *Gryphæa* and indistinct remains of plants.

Thickness .... 400 feet.

Jura:

Dark calcareous shales, covered by heavy beds of dark blue limestone, are near the base. Yellow shales and marls follow, with some thin interstrata of yellow or white sandstones. Some limestones above this. A series of yellow, white, pink, and greenish marls and shales close the formation. Fossils: *Belemnites, Gryphæa, Rhynchonella, Lingula, Modiola, Pecten,* and others.

Thickness .... 200 to 220 feet.

Trias:

Some light red and white sandstones near base, separated by thin beds of red or brown shales. Massive bright red shales, with dolomitic interstrata higher up. Heavy beds of red sandstone follow. Above these a series of red, pink, yellow, and white sandstones, some of the coarse-grained. Shales occur with these latter sandstones and close the formation. A decided thickening of the upper beds may be observed to the eastward. No fossils.

Thickness .... 800 to 1,200 feet.

Adding these figures, we obtain for the Mesozoic division of this region a total thickness of 2,500 to 2,920 feet.

POST-CRETACEOUS.

Laramie Group.

Along Beaver Creek we find a series of beds superimposed upon the Fox Hills group, which I refer to the Post-Cretaceous period. We have in adjacent regions a considerable development of the Lignitic strata, but here it is limited. It is not my purpose here to enter into any discussion as to the proper position of this group in the geological succession of formations. In a paper treating of the coal-beds near Evanston I shall shortly have occasion so to do. Overlying the upper sandstones of the Fox Hills we see a succession of shales and yellow sandstones forming low, long-continued bluffs. Our work did not carry us far enough to make any careful examinations of this group, but sufficient information was obtained to enable us to recognize the formation. Indications of coal were found at a number of points, but the large amount of debris covering the outcrops prevented any determination as to whether they were workable or not. So far as could be seen, the thickness of the group amounts to about 400 feet. Its horizontal distribution is determined, essentially, by the amount of erosion and transportation of material to which the overlying beds have been subjected. We find the beds exposed along a line trending about north 45° west, following the general strike of the strata. The dips, at this distance from the centres of disturbance, is almost obliterated, amounting to but a few degrees. A series of heavy, yellow sandstones close the Lignitic Group. Neither in topographical features nor in geognostic importance does this series occupy a very prominent position. From observations made elsewhere, we find that the group develops to a much greater extent farther south and southwest. It passes under the Tertiary beds and reappears in the southern portion of our district, occupying conspicuous areas.

I have placed the group under the head of "Post-Cretaceous" in conformity with the views expressed in the annual report of 1875. In this report I shall continue to do so, expecting soon to present a paper which defines the reasons for taking this position. Literature upon the subject is accumulating, but as yet it is impossible to say which opinions may ultimately be adopted.

TERTIARY.

During the past twenty years an almost endless number of Tertiary groups and subgroups have received names and have been placed into relatively different positions by various authors. We have, within the region to which this chapter is devoted, but one of the Tertiary groups, if we exclude the northern edge of the Sweetwater Plateau. This latter will be considered in the chapter next following, and mention of its geological character will here be omitted.

Wasatch Group.

Resting upon the yellow sandstones of the upper portion of the Laramie Group, we find a series of variegated, arenaceous marls. They are nearly horizontally stratified, and are carved into typical "bad-lands" by fluviatile erosion. A variety of colors presents itself in these marls. Gray and reddish-brown predominate, interchanging, however, with yellow, white, greenish, and maroon. Without any apparent separation of strata, these colors and shades form bands resembling well-defined bedding. Rapidly denuded by erosion, the slopes presented by these marls are generally entirely bare of vegetation. Thin bands of highly argil-

laceous sandstones, occurring sporadically within the series, sometimes give rise to the formation of low, regular bluffs. About 450 to 500 feet may be regarded as the thickness of these marls southeast of Beaver Creek, where we find them. The outlines of horizontal distribution shown by them are irregular, owing to the varied forms produced by erosion. In a general way, the western edge runs in a direction north and south, while the eastern passes beyond the limits of our district. From analogy of geological position and lithological character (no fossils having been found), I regard this series as parallel to Puerco marls of New Mexico and Colorado. They resemble them in every essential feature.

Above the marls we observe a succession of yellow sandstones and shales, which also belong to the Wasatch. They are cut short in their vertical development by the overlying beds of the Sweetwater Group. From certain features, subsequently to be discussed, it appears that a considerable amount of erosion must have taken place before the Sweetwater strata were deposited. This accounts for the imperfect vertical development of the Wasatch group at the point from which it has been described.

With the exception of a small portion of late Tertiary beds lying between the subsidiary range and the western base of the Wind River Mountains, we have no additional sedimentary beds to speak of in this chapter. The occurrence just mentioned will be reviewed, together with other Tertiary groups, in the fourth chapter.

POST-TERTIARY EROSION.

After the deposition of Tertiary sediment a period of great activity of a peculiar character existed within the area east of the Wind River Range. At that time, essentially, was the surface moulded into its present shape. Omitting the existence of most recent Tertiary groups, we can picture to ourselves the appearance of the country after the upheaval of the mountain range. The two main elevations were the range itself and the rise determined by the course of the anticlinal axis east of it. Erosion had, even before the advent of the latest tertiary waters, modified the surface very considerably. Upon the arrival of the latter, they found basins ready to receive the sediment they carried with them or derived from neighboring regions. In this manner an equalization of elevations and depressions took place, which greatly affected certain portions of the region. Subsequent to the deposition of large masses of Tertiary sediment a period of maximum erosion followed, which left the surface of the country approximately in the condition we now find it. Within the area to which this chapter is devoted we have occasion to observe the enormous effects produced by erosion. Final elevations along certain lines, or depressions on others, may, to-day, tend to magnify the results, but enough can be seen to obtain a general idea of its magnitude. Parallel to the strike of the sedimentary strata they have suffered severely from this primary erosion. Along the lines of disturbed portions, where the continuity of strata was probably broken and the rocks more or less shattered, the erosive forces have exerted a powerful influence. Nearly all of the material belonging to formations younger than the Carboniferous are composed of mechanically deposited sediment. This necessarily could offer but comparatively slight resistance to flowing water, and enormous masses of it were carried away to build up most recent groups at some other locality. Along the junction line of Carboniferous and Triassic beds this feature of erosion, denuda-

tion, and transportation can be admirably studied. A large portion of the lower country east of the anticlinal fold was at one time higher, but was gradually reduced by the persistent abrasion and removal of portions of its strata.

EVIDENCE OF FORMER GLACIERS.

In the Wind River Range the most complete evidence of extensive glaciers formerly existing there was obtained. Many of the small valleys and cañons at the southern end of the mountains show accumulations of glacial drift. In the immediate vicinity of Camp Stambaugh we find the gravel and drift adjoining small streams to be composed of rocks with which their drainage has at present no connection. Near the post there occurs, within the metamorphic area, a local deposit over 70 feet in depth, consisting entirely of drift material. It is located along the sides of a narrow gulch, and contains gravel and bowlders from the size of a pea to such weighing half a ton. As will be seen subsequently, we have evidence farther south which permits us to regard this as a *ground moraine.* On the western slope of the range evidence of former glaciers can be obtained as soon as we reach high elevations. Near timber-line we find numerous small, shallow lakes. Not unfrequently these are surrounded on three sides by morainal deposits. The most striking examples of extensive glaciers that I had occasion to observe we found between the headwaters of the Sandy's and Muddy Creek. While riding through the dense timber there we encountered huge masses of exposed rocks *in situ.* Intervening spaces between them were filled with shallow ponds or swamps, showing the fact that the depressions containing them were mostly excavations directly in the solid rock. Wherever such rocks were exposed they showed a very remarkable smoothness, resembling the famous "*roches moutonnées*" in shape. Grooving and striation covered them, leading from the more elevated points to the lower ones. In a number of instances we found the polish of these rocks to be absolutely mirror-like. This condition continued until we reached timber-line. There the constant weathering action has loosened enormous masses of rock, which, falling down, have in part obscured the effects of glaciers. Following down the course of an ancient glacier west of Muddy Creek, we observed with much interest the definite traces it has left. Originating along the steep walls of a semicircular depression, the glacier first moved through a narrow, shallow valley. Touching rocky walls on either side, it swept these perfectly clean, smoothing and polishing the granites wherever it came in contact with them. As the valley widened the glacier spread laterally, until the width became so considerable that lateral moraines were deposited. Shallow, basin-shaped excavations, oval in form, were worn down into the hard rock. Most of them are now filled with small sheets of water. From there the ice moved downward along a steep incline, pushing before it enormous masses of bowlders, in the form of terminal moraines. At present these extend for several miles into the low country beyond the western base of the range. Their width amounts to about a mile and a half, and their thickness may be estimated at a maximum of 800 to 900 feet. As the climatal conditions caused a recession of the glacier, smaller moraines, composed not unfrequently of material taken from the older ones, remained to mark the gradual decrease of the moving mass of ice. This feature becomes more noticeable as we retrace our steps to the small lakes found high up in the mountains. In several instances terminal moraines have formed dams across shallow depressions which now

are filled with water. Eliminating the minor curves made by the moving ice, the length of this glacier must have been 16 to 18 miles. This is one of the largest, but in its effects may be regarded as a type for other occurrences in the same region. An interesting feature was often observed relative to the melting or gradual receding motion of glacial masses. For some distance entirely bare rocks frequently composed one-half or two-thirds of the surface over which we travelled. They were smoothed, grooved, and striated. Resting upon them were innumerable pebbles and bowlders, ranging in size from that of a goose-egg to several feet in thickness. Standing thus upon the smooth, inclined surface of a rock *in positu*, these erratic blocks looked as if they might have been left there only a year ago. No signs of weathering action were visible in either, and often the blocks were so delicately poised that it would seem as if a breeze could disturb their position. Entire "fields" of this character were found, showing the direction toward which the glaciers shrunk.

On the eastern slope of the range numerous glacial moraines were noticed; they are generally smaller than on the other side, a fact which is partly owing to the orographic configuration there existing. Beyond the metamorphic area the evidences of glaciers extend for a short distance only. In spite of the enormous masses of moving ice and accompanying bowlders, we find in the Wind River Mountains a confirmation of the rule that glaciers produce no radical changes in the character of any given region. By the abrading action of both ice and accumulations of bowlders and sand, projecting rock-ledges and points reaching out toward the glaciers have been removed. Excavations within valleys already existing have been made. Material has been taken from one or more points and has been deposited at others. In other words, the detail features exhibited by the localities through which or over which the ice has passed have been *modified*. This limits the extent of changes wrought by glaciers.

When first I saw the enormous accumulations of snow and stationary ice in the main chain of the range (at the end of July), I fully expected to find active glaciers within its deeper cañons. In this I was disappointed. The extremely "fresh" appearance, however, that many of the occurrences above described exhibit has induced me to believe that glaciers existed in the Wind River Mountains until within a very recent period. Indeed, I should not be surprised to hear at any time of the discovery of moving ice-fields of small extent within the deep cañons of this range.*

LAKE DEPOSITS.

Within the region east of the Wind River Mountains we found a number of alkaline lakes of small extent, and beds of others that were dry. Although these, in a certain sense of the word, can be termed "lake beds," they are not to be considered here. On Beaver Creek, about 6 miles below its sharp turn to the northward, we found an extensive lake deposit. Fine arenaceous clay, silt, and sand have here been deposited in a large, level valley. Conformable to the color of the original material from which this drift was derived, we observe alternating bands of red, gray, yellow, and brown deposits. Varying with the color necessarily we find the different layers showing some changes in their composition. We had no means at hand to determine the thickness of this accumula-

*NOTE.—During the past summer (1878) active glaciers of small extent have been discovered in the Wind River and Teton Ranges. The large masses of snow during the summer of 1877 covered them entirely, so that we passed over them without recognizing their existence. In the Annual Report for 1878 full descriptions of these glaciers will be given.—E.

tion of redeposited material. From observations made along the banks of the creek it appears to be more than 20 feet thick, however. This is the only lake deposit of any importance that was seen in this region. A few *Helices* found in it crumbled very easily, showing that they have been included within this drift for a long period of time. During the season of high water large masses of the loose beds are washed away and transported toward the north.

DRIFT.

The different varieties of drift that are usually found in the mountains and flat country were observed within this region. *Avalanchial* drift covers the sides of the mountains above timber-line. Frequently enormous rock-slides extend downward for some distance, sweeping before them the timber that may be in their way. In the steeper portions of the main chain we found accumulations of angular rock-fragments that evidently owe their present position to the agency of snow. Avalanches starting during the season of first thaws carry along bowlders from the adjacent mountain sides, which are deposited in moraine-like arrangement. Dependent upon the character of the rocks composing this class of drift is the shape and size of the bowlder. In the higher regions of the Rocky Mountains avalanchial drift represents a type of considerable importance. Due to this in a great measure is the characteristic barrenness of the mountain-slopes.

River drift occupies the valleys of all the streams of any size. Those creeks and rivers that have any considerable drainage within the metamorphic area carry drift composed of such material with them for a long distance. Some of the valleys are covered entirely with coarse drift, an occurrence which is due to the parallel shifting of streams along their general course. The ultimate result of gradual disintegration of river drift is the production of silt and sand. Silt is not unfrequently found in connection with glacial lakes. Constant diminution of the transported material, more particularly of that constituting the ground moraine, results in the formation of this silt. In river bottoms, and near small streams, a slightly different process produces the same effects, requiring more time, however.

SOIL.

In the lower valleys we find an abundance of soil. Along the Big Popo-Agie and its immediate tributaries the soil there accumulated has been utilized by settlers for agricultural purposes. Many of the lower valleys might be made similarly useful, were the supply of water sufficient for irrigation. The decomposition of shales, sandstones, and marls furnishes good rich soil. Nearer the mountains limestones enter into the composition. So far as I could learn, the soil, wherever cultivated, yields good crops. On some of the small creeks good bottom-lands are found, containing rich soil, which may eventually become fruitful. At present, grass and willow brush are the only vegetable products.

RÉSUMÉ OF THE GEOLOGY OF THE WIND RIVER RANGE AND THE REGION EASTWARD.

Reconstructing the original conditions as existing in the region of the Wind River Range prior to the great era of metamorphosis, we observe some very interesting facts. For the reason that other portions of our district, not yet described, enter into consideration in this question, a complete synopsis of the former conditions cannot be now presented.

Enough may be said, however, to indicate which groups appearing in other chapters pertain to the subject under discussion. From what we have observed, we are enabled to say that at the earliest geological periods a narrow range existed, trending approximately E. 50° S. Against the northeastern side four distinct types of sediment were deposited. That this occurred at long intervals of time, during a period of more or less disturbance of *niveau*, is evident from the horizontal projection that we can assume for these groups. Such assumption is based upon the study of the series as it now appears—metamorphosed. Applying lithological nomenclature in order to make clear what is meant, we may say: The Prozoic granite is the remnant of the original range; against this were deposited the old metalliferous schists; granite composing the main chain followed; this was succeeded by a narrow band of schists; and the fourth or last group is represented by the younger granites. In case we make an attempt to indicate the original, unchanged condition of these rocks, we may regard them as representing siliceous shales (*schists*) and more or less argillaceous sandstones (*granites*). As the earth is but a body "buried beneath its own ruins," we cannot expect to find aught but what is contained in the original crust. Schists and granites or siliceous shales and sandstones, therefore, are essentially the same thing, varying only in the percentages of component parts. It appears that the lowest Silurian strata were deposited before the thorough metamorphosis of the entire mass took place, unless, indeed, we account for the change in the sandstones by assuming a generation of heat during the period of mountain elevation.

In these very earliest deposits we observe an "overlapping" of the groups. The metalliferous schists are soon hidden from sight by the preponderance of the main chain granite. Eventually this, as well as the younger schists and granites, disappears at another point. This is due probably to pinching out of the groups in certain directions rather than to a lateral inequality in the propelling force which caused the elevation of the mountains. If the latter cause had resulted in the production of this phenomenon, we would find it accompanied by others which we now do not observe.

Sedimentary formations reach an ample development in this region, considering the disadvantageous locality at which they were deposited. We had at the time of the Silurian, for instance, a more or less elevated ridge, sloping toward the northeast. So far as our observations enable us to determine, we find that the influx of waters came from that direction for a very long period of time. While elsewhere the waters could attain great depths, they were here necessarily shallow, and the amount of material deposited within them must stand in proportion. Thus we find that a number of formations and groups, greatly amplified to the north and northeast, have had but little opportunity to reach any extensive vertical development in the vicinity of the Prozoic range. Changes of *niveau*, which took place probably during long periods of time, permitted some of the younger groups to reach proportionately great thicknesses.

Of the Silurian formation we have representatives of two groups. Both of them are characteristic, and are very frequently found in the same relative position throughout the Rocky Mountains. The Carboniferous formation is well represented by the two lower groups, which can generally be distinguished. It is with some reluctance that I regard the series of strata above the blue limestones as Permian. Usually this formation carries some typical fossils, but in this instance none were found. A decided similarity of the rocks and the unequivocal position

occupied by the group decide me to determine it as such for the present. If this should be proved by subsequent investigations not to be Permian, it will necessarily be added to the lowest Mesozoic formation. Although many miles were travelled during the past season in the "red beds," we are not able to throw any additional light upon the question touching their true position. The direct superposition of undoubted Jurassic beds draws the limits rather closely, but we must still look forward to some palæontological discovery that will set all doubts at rest. In the preceding pages I have spoken of this formation or group as the Trias (without query), but define this as not indicating that I desire to commit myself upon the point. I am of the opinion that eventually this identification may prove to be the correct one, but up to the present time it is not yet established.

The anticlinal axis, which has frequently been mentioned above, is a very interesting feature of the region. As it passes beyond the limits prescribed for this chapter, a connected discussion thereof shall be postponed until later. Jurassic beds are satisfactorily developed, occupying a definite horizon between the red beds and the lowest group of the Cretaceous formation. Although they do not compare favorably, from a palæontological point of view, with the occurrences farther north, the evidence obtained is entirely sufficient to establish its geological position beyond a doubt. Groups younger than the Jurassic are developed in regular succession and require no further mention.

One of the most interesting features of the Wind River Range is found in its evidence of abundant glaciation. No mountain region that I have had occasion to visit in the West shows so strikingly the enormous effects produced by the action of moving ice. Nearly the entire western slope, so far as it lay within our district, must have been covered with successive ice-fields. They have left their history written in unmistakable, ineffaceable language upon the rocks which once they covered. Climatal conditions since that period have undergone a change, and we are enabled by reading the writing transmitted to us to construct a picture of what at one time must have been the conditions of this section of the country. In the annual report for 1875 I have given my views with regard to the former existence of glaciers in the Rocky Mountains. Although based upon observations made in regions 4 and 5 degrees of latitude farther south, the general conclusions will apply equally well here.

Taken as a whole, the country to which this chapter is devoted is one replete with interest. We miss in them, however, the occurrence of erupted rocks. Whether the anticlinal axis has been caused by their action, without their having broken through to the surface, may, for the present, remain an open question. No evidence either for or against such a supposition was obtained within the region above described.

CHAPTER III.

GEOLOGY OF THE SWEETWATER VALLEY AND ADJACENT REGIONS.

ELEVATED AREAS.

The region to which this chapter is devoted comprises an area containing all the Sweetwater drainage except that which enters into the river within the metamorphic rocks. It forms a belt about thirty miles wide, trending east and west. Longitude 107° west forms the eastern terminus, while the western is located a short distance west of the Little Cañon of the Sweetwater.

Two small ranges of hills occur within this section. The one is that of the Sweetwater Hills with their eastern extension, the Seminoles, while the Granite Hills north of the river form the other. Orographically both of these are very simple, the former being merely an upheaved chain, and the latter a group of rocky islands in a tertiary basin. Besides these two small ranges a considerable elevation is reached by the Sweetwater Plateau at its northern termination. I regard the western end of the Sweetwater Hills, considering it from the standpoint of a geologist, as being defined by the most westerly outcrops of the granitic hills south of the river.

In order to present very briefly some of the most striking characteristics of these hills, a few words may here be said in regard to their structure. We may essentially consider the Sweetwater Hills as a small anticlinal range, forming a continuation of the anticlinal upheaval east of the Wind River Mountains. In their more elevated portions, all metamorphics have disappeared, excepting those which, in the preceding chapter, have been regarded as the youngest ones. Throughout the entire eastern extension of the hills this character is maintained and is made very apparent by the position of the sedimentary strata. Analyzing this structure more carefully we find that in this instance the southeasterly extension of the anticlinal axis coincides with the axis of elevation manifested by the Wind River Range. We have, therefore, an anticlinal fold augmented by the force of general upheaval. This results in placing the younger formations into more prominent positions on the north side of the hills than on the south. When the maps of the district shall have been prepared I will be better able to demonstrate this fact. So far as possible, I will do so in the subjoined pages by presenting a series of approximate parallel sections which will furnish some idea of the relative distribution and position of strata.

DEPRESSED AREAS.

Of these we have but one in the region under discussion. It is the valley or, geographically speaking, basin of the Sweetwater. Sloping toward the river, both from the north and south, a shallow depression is formed, which is cut into two parts of unequal size by the river. In the

preceding report upon the topographical features of our district this subject has been more fully discussed. Geologically, this low area is of the greatest importance, and furnishes very acceptable hints as to the early history of the country.

PROZOIC.

It will be remembered that the subsidiary range west of the Wind River Mountains is composed of Prozoic rocks. They disappear under the metalliferous schists of the Stambaugh region and remain hidden for some time. We next find them at the western termination of the Sweetwater Hills. Here they appear as a group, trending approximately east and west, composed of disconnected hills. Bare of vegetation and rugged, they present a very typical aspect. The granites composing these hills are entirely structureless, forming huge, irregular masses. Red and flesh-colored orthoclase, white and gray quartz, and muscovite are the constituent minerals. Toward the southern edge of this group we find that either loose drift or Tertiary strata reach directly to the granites, covering whatever older formations may be beneath them. On the north side Carboniferous strata rest upon them, preventing the appearance of Silurian beds which undoubtedly occur there.

An interesting feature was observed in these granites, which I failed to notice in the subsidiary range, the occurrence of basaltic dikes. Varying in width from 4 inches to 10 feet these eruptive rocks closely fill fissures in the granite, striking as a rule northeast and southwest. Although the granites decompose and disintegrate but slowly, we find some localities where the dikes project for several feet above them. Generally they appear on the surface simply as black bands, conforming entirely to the details of weathering and cleavage shown by the rock enclosing them. In lithological character, mode of appearance, and general relations to younger formations, these granites appear to be almost absolutely identical with those farther west.

Following the line of granitic outcrops of this region in an easterly direction we find them covered by Palæozoic and subsequently these by Cenozoic formations. Curving somewhat to the north we cross the Sweetwater Valley and find ourselves in the continuation of the granites just described. It is formed by the Granite Hills directly north of the Sweetwater. By all explorers who have ever visited this region has been noted the remarkable barrenness of these hills. Frémont says:* "Except in the crevices of the rock, and here and there on a ledge or bench of the mountain, where a few hardy pines have clustered together, these are perfectly bare and destitute of vegetation." Dr. Hayden, in his report upon this region,† describes the Granite Hills as follows: "All around the flanks of these granite ranges the same Tertiary beds jut up without any interruption, and are smooth and even, so that the granite masses seem to rise abruptly out of the plains. A few stunted pines struggled for existence among the crevices, and some rare shrubs and ferns were all the vegetable life observed." The absolute nakedness of these hills is truly remarkable. Without any definite rock structure they rise directly from the plain, presenting their bald, gray and red forms, which rise to a relative elevation of 300 to 1,100 feet. Smooth, rounded surfaces of considerable extent render the ascent of some of the higher peaks almost an impossibility. Toward the centre of the group or range we find the hills connected with each other by ridges, mostly bare, but sometimes covered with short grass.

* Rep. Expl. Exp. to the Rocky Mts., 1842. Washington, 1845.
† Rep. U. S. Geol. Surv., 1870, p. 30.

Studying the detail-features of the hills we find that they are composed mainly of a coarse red granite. The effect produced by atmospheric influences has been to destroy the red color in some instances, and we then find it gray. Upon reaching the base of a hill the first impression obtained is that of an enormous pile of huge granitic bowlders heaped together. Orthoclase, quartz, and muscovite compose the main portion of the rock. Toward the northern limits of the group some hornblende and chlorite may be observed. There, too, we find some of the younger granites. At several points the prevalence of orthoclase is so great as to produce apparent stratification. It will be found, however, that the divisions simulating strata all run in curved, short planes. Numerous dikes of basaltic rock were observed within these granites, varying in thickness from two feet to several hundred. In some instances the dikes exhibit columnar structure. At right angles to the enclosing walls the material has segregated into smooth-sided but irregular prisms. An occurrence of this kind may be seen at the Devil's Gate. It will be remembered that this euphonious title has been given to a vertical opening in the granites, about 5 miles west of Rock Independence. A narrow granitic ridge extends to the southward from the main group, and is cut by a deep gap. The walls of this gap are about 400 feet above the Sweetwater River, which flows through it. From some remnants we can see that originally this fissure was filled with eruptive material which was segregated into columns. Due to this latter fact is the greater power that erosive agents could exercise upon the enclosed mass, and it was gradually removed. Dr. Hayden supposes, and I agree with him, that formerly the river curved to the southward, flowing around the granitic ridge, until finally it found its way into the gap and aided in the destruction and removal of the dike.

Both the analogy of composing minerals and the characteristic occurrence of dikes connect the Granite Hills with the outcrops at the western end of the Sweetwater Hills. Although a number of instances were observed where the dikes penetrated granite which was overlaid by younger rocks, the erupted material invariably stopped with the granite, showing that its age is very great. The area occupied by the Granite Hills has approximately an oval shape. Both west and north we find isolated outcrops, rising to relative elevations of 600 to 700 feet. Toward the east the hills assume a southeasterly trend, and are crossed, by way of the Devil's Gate, by the Sweetwater River. One of the isolated exposures of this granite is formed by Rock Independence. Dr. Hayden, in 1870, made some measurements of this historic block. He found the circumference of the granitic rock to be 1,550 yards; the height of the north end 193 feet; that of the southern 167 feet. Near the middle, between these two high points, there is a depression, so that there the relative elevation is not more than 60 feet. Beyond Rock Independence the granite passes out of our district.

Connecting the three exposures which I regard as belonging to one series, we obtain an old granitic range of considerable length. It shows a slight S-shaped curve upon horizontal projection. Between the eastern end of the subsidiary range and the western beginning of the Sweetwater Hills there was a decided depression, permitting the granites to be hidden from sight by the succeeding sedimentary formations. A similar depression existed in the space intervening between the last-named outcrop and the Granite Hills. From all that I have seen throughout this region I have come to the conclusion that the continuity of these three groups may be regarded as having formerly existed, and that the granite composing them is the oldest rock in our district.

From the sections which are given below, the relative position of this Prozoic granite will be seen. So far as could be determined, this most ancient range was but very little affected, locally, by the great dynamic disturbances which succeeded the close of the Cretaceous era.

During the early Palæozoic period this low range, which then occupied a much higher relative position than at the present time, formed an effective barrier to the southwestward progress of the waters. We find, therefore, that on the southern slope of the granitic groups the older sedimentary formations occupy a very subordinate position, except at such points where the low elevation of the range permitted the passage of waters in which the sediment was deposited. We may regard the strata deposited during the older sedimentary period north of this range as the terminal edges of the extensive areas to the north and northeast. An exception to this occurs, however, along the former depression between the granites of the western end of the Sweetwater Hills and those of the Granite Hills. There free access was afforded, and as a result we find the sedimentary beds of the eastern Sweetwater and the Seminole Hills.

METAMORPHICS.

In the preceding chapter it has been stated that the metalliferous metamorphics extended for some distance down on the Sweetwater. Their last appearance on this river is found in the Little Cañon west of Saint Mary's ranch. At this point they are directly overlaid by Potsdam quartzite. We observe that the metamorphic granite, which is elsewhere interposed between these schists and the Silurian strata, is entirely eliminated. This may be accounted for most readily by the assumption that the old schists here reach their greatest horizontal and vertical development. In consequence of this the extreme border of the granites does not reach so far south. The nearest point where the granite crops out again is south of Sheep Mountain, on the line of the anticlinal upheaval, where Potsdam quartzites are found resting upon it. To the south of the river the schists are covered by Tertiary beds, determining the limits of the group. Within our district this schist does not again make its appearance.

Metamorphic granite is found in the Sweetwater and Seminole Hills. It is composed of orthoclase, white and yellow quartz, muscovite, and some oligoclase. The exposures we find in these hills are, in my opinion, a continuation of the youngest granites appearing on the eastern slope of the Wind River Range. After the continuity of the granite in that region is broken we first find it again south of Sheep Mountain. There it occupies its present position by virtue of the anticlinal fold which passes through in a direction south of east. Again we find a small exposure near the Sweetwater, about 12 miles below Saint Mary's ranch. From that point we must travel in a more easterly direction, about E. 20° S., in order to find another outcrop. It is once more met with in the Sweetwater Hills west of Elkhorn Gap. Ascending the mountain directly west of the gap, we find the entire summit and the higher portions of both the north and south slopes composed of granite. It is here too much weathered to show any definition of stratoid arrangement, but from the shape of the hill and its trend we may infer that we stand upon the crest of an anticlinal uplift. Proceeding westward on this flat-topped hill we find the granite gradually pinching out, until we reach a group of sedimentary beds dipping steeply toward the south. Several of the formations from the Silurian upward are here exposed, while the granites have sunk down low and are covered by the strata of the Sweetwater Group.

Directly east of Elkhorn Gap we meet with considerable difficulty in disentangling the intricacies of stratigraphical disturbances. We find that from that point to the termination of the hills at Whiskey Gap, the main bulk is composed of the same metamorphic granite. Descending from the summit we find a series of sedimentary beds folded so as to be completely overturned. Beyond these granite occurs again. So far as can be determined without the aid of analysis and microscope, the two granites are entirely the same. The second group, perhaps, shows more decided structure. The two granitic outcrops run parallel with each other until the smaller one is lost under the strata of the Sweetwater Group.

As we approach Whiskey Gap we find that the main granite of the hills comes to an abrupt termination, and that the ridge immediately opposite is formed by sedimentary beds trending in the same direction. Crossing the gap we observe a dip of the sedimentary strata toward the southwest, but as we go farther east this changes to south, and the granite sets in again. Encroaching upon the sedimentaries this forms the northern slope of the hills, while the highest portions are formed by Palæozoic strata. As we reach Sandy Creek Pass we see that the granite has monopolized the bulk of the hills, and that the sedimentary beds still retain their southerly dip.

In preceding pages I have termed the structure of the Sweetwater and Seminole Hills an anticlinal one. It remains to be stated that the sedimentary strata on their immediate slopes afford but little evidence touching this point, but from the glimpses which could be obtained of beds underlying the Sweetwater Group, this must necessarily be the type of the hills.

The northern and northwestern portions of the Granite Hills show a difference of structure which led to a more careful examination. It was found that instead of being composed of the same Prozoic granite as the main mass, they were formed by stratified granites, with some hornblendic schists. Owing to the isolation of the outcrops, it was a difficult matter to reduce them to a system. Enough was seen, however, to indicate that they stand in close relation with the anticlinal upheaval which is marked as *B* in subsequent sections. Toward the eastern termination of these metamorphics their stratification is particularly plain. It is so apparent, that from a short distance, even, I supposed the rocks to be unchanged sedimentary. The suspicion presented itself that some of the Silurian beds, which elsewhere are found unchanged, might have furnished the material for the granites and hornblendic schists here observed. This could not be proved, however, as the superincumbent Tertiary beds prevent all study beyond the immediate surface of this locality. At this point the areas occupied by metamorphics are detached and of small extent. Dips may be observed which indicate participation in the anticlinal fold above alluded to.

For the purpose of elucidating the interesting features connected with this range, as well as to show the relations between the oldest rocks of the region, I have constructed a series of parallel sections. They run from south to north, in every instance cutting the Sweetwater River.

Section III is taken along a line east of Camp Stambaugh. I have indicated the existence of the Prozoic granite (*a*) at some depth. Emerging from under the Tertiary strata (*T*) we find the metalliferous schists (*b*). They are covered, in part, by Potsdam Quartzite (*d*) which appears in the Little Cañon of the Sweetwater. From the evidence obtained farther northwest, I have indicated the younger granites (*c*) covered by the regular

succession of sedimentary formations. At the northern end of the section the effect of the Sheep Mountain anticlinal (*A*) has been indicated.

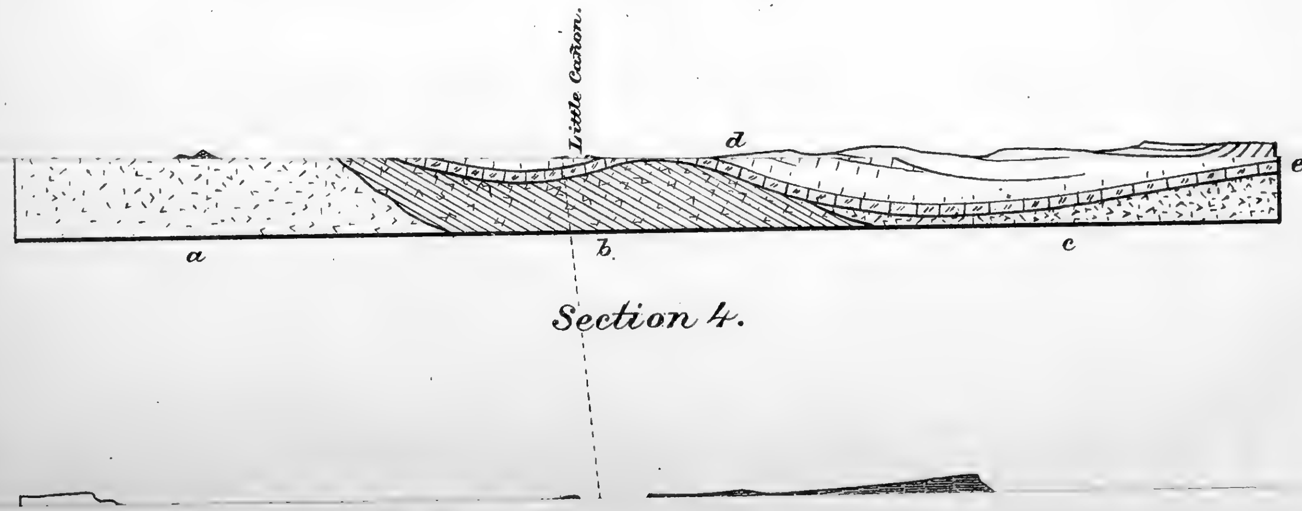
Section IV runs south and north a short distance west of Saint Mary's Station. It cuts one of the old granitic hills (*a*). Resting against this the schists have been represented in diminished quantity. They do not appear upon the surface. Carboniferous limestone (*f* and *g*) are found on a line toward the Sweetwater, dipping northward. Tertiary strata cover them for considerable distance. Passing down the steep northern slope of these latter, we reach older sedimentary formations, and with them the continuation of the anticlinal upheaval (*A*). The line of elevation continued from the Wind River Range is marked in both sections as *E*. It is obscure, but can occasionally be found.

Section V is taken along a line a short distance east of Saint Mary's ranch. The old granite (*a*) is almost entirely hidden by superincumbent Tertiary beds (*T*). Resting upon the Prozoic rocks the schists (*b*) have been sketched as forming but a small deposit, while the younger granites (*c*) are advancing toward the south. We know of their existence in that region as well as of the presence of the anticlinal fold (*A*) through some small outcrops that were found. North of the edge of the Sweetwater plateau (*P*) we find the sedimentary strata undisturbed.

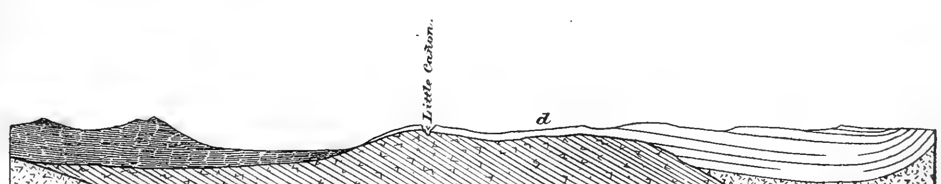
Section VI runs along a line about 2 miles west of the first granitic hills north of the Sweetwater. From the south everything is obscured by Tertiary deposits. At the river we observe the appearance of both Silurian and Carboniferous strata. I hold the view that this is produced by the effect of the anticlinal axis (*A*), which here coincides with the axis of main elevation (*E*). In this section we pass the region of minimum elevation of the oldest granite. To the northward the Prozoic granites are indicated as reaching nearly to the surface, while the younger granite extends still farther south. Near the northern end of the section, the effect of the second anticlinal (*B*), which has been mentioned in Chapter I, is introduced.

Section VII cuts along a line about 13 miles west of Sweetwater Gap. We there observe the reverse of what was seen in section IV. From the south the Tertiary bluffs (*T*) extend high up, obscuring everything. North of those we find a series of sedimentary formations dipping to the southward at very high angles. A narrow line of metamorphic granite (*c*) runs along the outcrop of Potsdam sandstone (*d*). North of this granite the Sweetwater Group covers the entire region to the base of the Granite Hills. Underlying these the older sedimentary formations have been represented. Travelling eastward from that line we find that the sedimentary beds rapidly disappear, but that the granite. takes a turn to the southeast, and rises to a considerable elevation. It there forms the main bulk of the Sweetwater Hills. Both the north and south slopes are entirely obscured by Tertiary strata, so that nothing further of the structure can be seen. I ascribe this rise to the effect of the anticlinal upheaval (*A*) which has continued in its general direction until it reached this point. The southerly portion of the strata, having been pushed high up, still remains, while their northern continuations either never reached the same elevation, or were eroded and are now covered by Tertiary beds.

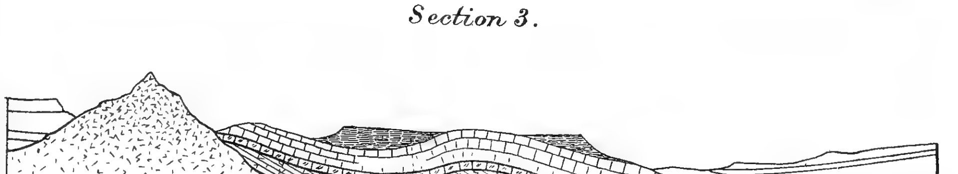
The granite continues to Elkhorn Gap, and from there eastward forms the central portion of the hills to Whisky Gap. Section VIII, taken a short distance east of the former, shows the main granitic mass occupying the points. Another granitic outcrop (*c*) corresponds with that farther west in its action upon the strata of sedimentary formations. So far as could be determined, these originally sloped from the northward,



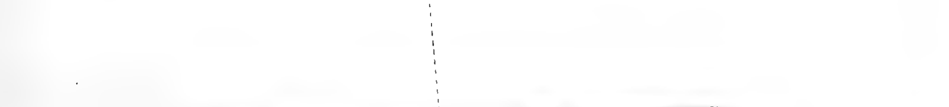
Section 4.



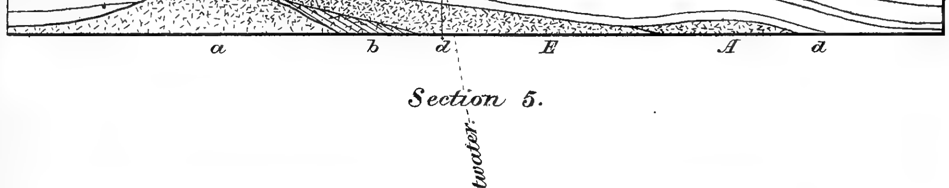
Section 3.



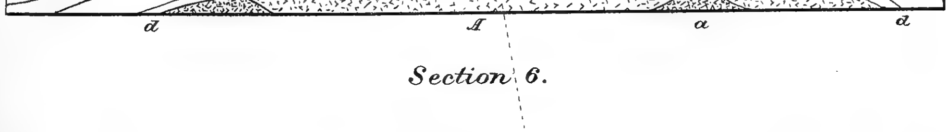
Section 4.



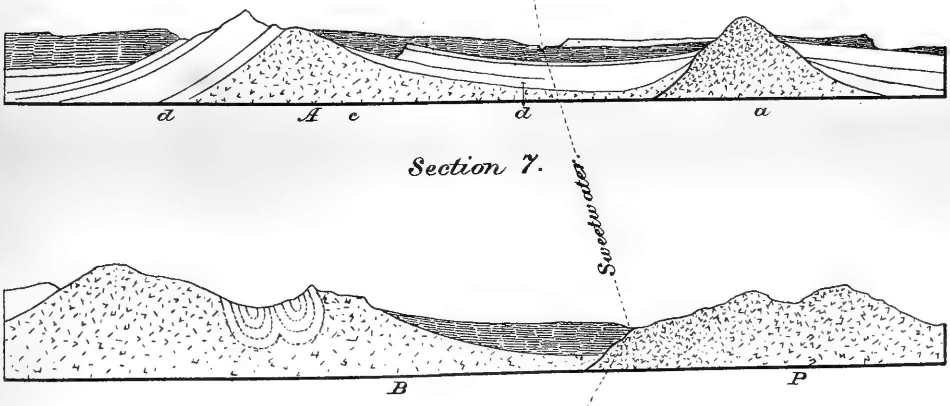
Section 5.



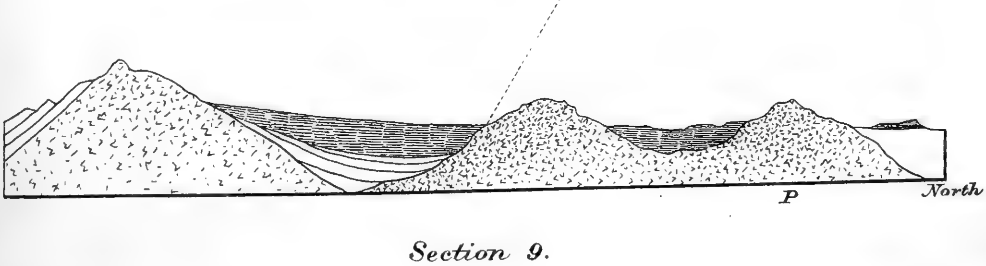
Section 6.



Section 7.



Section 8.



Section 9.

F.D.O.

occupying but a small area on the side of the hills. By the protrusion of this newly-appearing granite, the beds have been very much disturbed, and in several instances directly doubled up. I regard this phenomenon as due to the influence of the anticlinal upheaval designated as *B*. Throughout the Sweetwater Valley no evidence can be found of it except near the western border of the Granite Hills. Possibly this upheaval has nothing to do with the occurrence, but in this case its peculiarity could only be explained by the acceptation of an independent elevation along a line parallel with the trend of the hills.

Following along the summit of the hills, we find that nearly all of the northern slope is obscured by Tertiary strata and drift. Granite continues to form the central mass. On the south side younger sedimentary strata dip off from the granites. At Whiskey Gap the connection between the latter is entirely broken.

The granite of the Sweetwater Hills comes to an abrupt termination, and the succeeding range shows its highest points occupied by sedimentary beds. At this locality the disturbing granite (*c*) evidently makes a subterranean curve, but appears again a short distance east of the gap. This condition of structure is illustrated by section IX.

We find the granitic area gradually widening as we go eastward, pushing the sedimentary beds toward the southeast. Dipping steeply at first to the south, they gradually assume a more gentle inclination. Bed follows bed until the younger Cretaceous strata are reached, which eventually form the low country extending toward Fort Steele.

In no instance do the sedimentary beds appear with a northward slope on the north side of the granites. It might be supposed that they were elevated and pushed beyond the vertical, but the order of the beds would in that case necessarily be inverted. We have evidence at a number of points that the Sweetwater Group covers older sedimentary strata reaching down to the Silurian, and I am inclined to ascribe the absence of such groups on the north slopes of the hills to the effects of early erosion. When the maps shall be completed I will be able to present horizontal sketches of the former and present of this region which region which will make clear the dynamic actions involved. At first sight they appear complicated, but they can readily be reduced to a comparatively simple system.

PALÆOZOIC FORMATIONS.

SILURIAN.

At a number of localities within the Sweetwater drainage we find Silurian strata. In part they are a direct continuation from the region farther northwest; in parts they appear after having been hidden for some distance by superincumbent strata.

Potsdam sandstone.

A good exposure of the red quartzites belonging to this group is found near the Little Cañon of the Sweetwater. The wagon-road leading to Stambaugh crosses the upturned strata. In accordance with the position and configuration of the schists upon which they rest, the quartzites show an easterly dip amounting to about 30°. They form a portion of the cañon walls. Trending in a southeasterly direction, they are soon lost, however, within the Prozoic Group at the western end of the Sweetwater Hills. I do not recognize them with certainty. Going

to the eastward, we meet with the first extensive outcrops on the north side of these hills, at the locality which is cut by Section VII. Resting upon a narrow band of granite, the red quartzites stand nearly vertical, decreasing slightly in dip as they continue southward. Near a small creek in that region they have been raised to an elevation of about 500 feet, forming a prominent hill. To this region their thickness is about 400 feet. As in the vicinity of the mountains, so here we observe a number of variations in the quartzites. Generally they show a rusty red color, occasionally deepening into a dark brown. Near the top some lighter strata occur, of pink, yellow, and white color. From there they do not appear again in the hills until we reach Elkhorn Gap.

Near the western termination of the Granite Hills a prominent anticlinal upheaval is observed in the sedimentary beds just north of the Sweetwater plateau. Its continuation extends toward the southeast. South of the point where the disturbed beds join the plateau edge, a small cañon is formed, through which the river finds its way. The walls of this are composed mainly of Potsdam quartzite. Although the rent does not occur exactly on the vertical axis of the anticlinal which reaches this region from Sheep Mountain, I am inclined to ascribe its formation to this cause. It is apparent that the strata here, which dip at angles varying from 15° to 20° to the north and northeast, form the northern side of the anticlinal, which in the sections has been marked *A*. For a short distance only are the quartzites here exposed, disappearing under the beds of the Sweetwater Group.

Directly east of Elkhorn Gap, on the north side of the hills, we find a rather extensive outcrop of the same strata. Rising at first apparently directly out of the Tertiary beds adjoining, we soon find the cause of their elevated position by examining the country a very short distance farther east. Dipping toward the northeast at an angle of 80° to 85°, the quartzites form sharp, prominent hills. We find them resting upon metamorphic granites, which gradually increase in height and area toward the east. Near the centre of the hill the granite is once more covered by Tertiary beds, but the quartzites remain exposed. Enormous masses of glacial drift render it impossible to follow the line of outcrop, but the recurrence of the Potsdam quartzites only a short distance west of Whiskey Gap proves the underground connection. Throughout the entire line they stand nearly on end, evidently having been pushed up with great violence.

East of Whiskey Gap, we find the continuation of the series, flanking the Seminole Mountains on the north side. Crossing Muddy Creek, we notice a narrow line of red quartzites, trending approximately east and west. They stand vertically or dip at a very steep angle to the south. The same granite which has produced their elevation near Sweetwater Gap now appears in the same relative position. It forces the quartzites high up into the Seminole Hills, making up almost the entire eastern slope.

Calciferous Group.

At the most westerly outcrops of the Potsdam quartzites the calciferous series has shrunk to a minimum. Farther east it is represented by a series of gray and yellow dolomites, partly arenaceous, which are of very little importance, however. In stratigraphical arrangement and in participation in folds and plications, the beds of this series are thoroughly conformable with those underlying.

In the two Silurian Groups but very few fossils were found throughout this region. *Lingula* occurs in the quartzites, and a number of poorly

preserved *corals* were noticed in the dolomites and magnesian limestones. The great strains to which these members of the Silurian formation have been subjected have resulted in numerous joints and fractures. This feature is particularly noticeable in the quartzites, which weather in sharp, angular bowlders.

CARBONIFEROUS.

Subcarboniferous.

Occupying the same relative position as it does farther to the northwest, we find the Subcarboniferous strata within the region of the Sweetwater drainage. Composed of the same beds here as there, they are found underlying the massive blue limestones of the Carboniferous Group. Near the Little Cañon of the Sweetwater the dolomites and sandstones belonging to the group overlie the Potsdam sandstones. A large portion of them are hidden by the Tertiary beds, which there occupy disconnected areas. At the western end of the Sweetwater Hills the dolomites mostly rest directly upon the Prozoic granites, dipping, generally, to the northward and northeast. They are covered by the Carboniferous series, which, in turn, is hidden from sight by the overlying Tertiary beds. In the Sweetwater and Seminole Hills, as well as directly west of the Granite Hills, the Subcarboniferous Group is thoroughly conformable with the Silurian. Its thickness may be estimated as varying from 700 to 900 feet, increasing toward the east. Very few fossils were found, all of them in an exceedingly poor state of preservation.

Carboniferous Group.

In the region of the Sweetwater the Carboniferous Group becomes of considerable importance. Appearing first in connection with the Silurian beds near the Little Cañon, the blue limestones are covered to the southward by Tertiary deposits. They are again exposed in the area of the granitic hills south of the river. Occupying either the slopes of these hills or forming ridges which trend about N. 45° W., they dip toward the north and northeast. Nothing further is seen of them until we reach the western end of the Granite Hills. At the northern edge of the plateau we find some very interesting outcrops. We see there the effects of the termination of an anticlinal upheaval. It is essentially one of that character which Dr. Hayden regards as typical for the entire region. They occur in Dakota, Wyoming, and adjacent Territories. By the upheaval an arrangement of strata has been produced which forms an oval or long-drawn quaquaversal fold. In this instance the Subcarboniferous strata are the lowest ones exposed, as the presence of the Granite Hills probably prevented the carrying up of older strata. By this same upheaval the younger granites to the northwest of the Prozoics have been raised, but not sufficiently high to produce a rupture of the Carboniferous beds sufficiently great to let the Silurian strata appear. Two sections (X and XI) will illustrate the conditions here existing. The first one runs approximately north and south, the second east and west.

Beginning at the southern end of Section X we find the Tertiary beds (*i*) overlying Carboniferous (*d*). In this line we cut the point on the Sweetwater, where it flows through a narrow gorge of Silurian and Carboniferous strata. This is located near the continuation of the anticlinal fold which in previous sections has been marked *A*. North of the river the limestones dip at an angle of 15°. They are soon covered again by Tertiary strata, but reappear, dipping southward 8°. The obscured

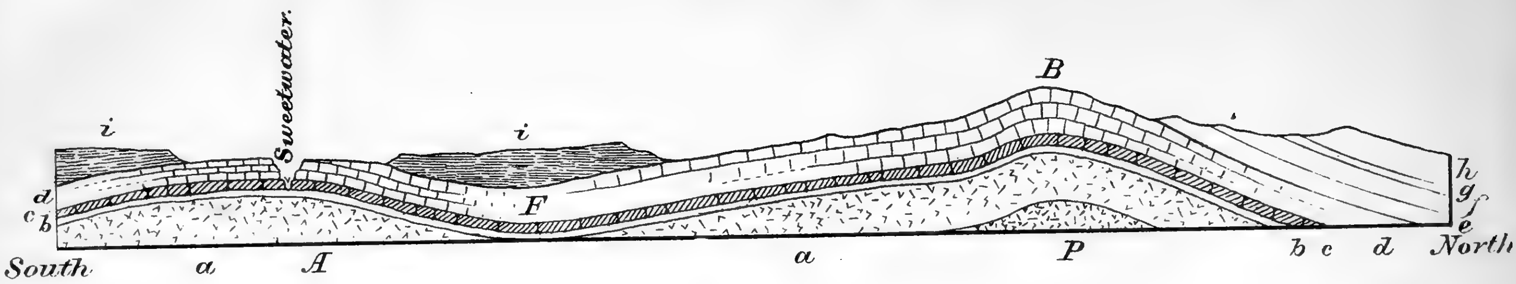
portion must therefore most likely contain a shallow synclinal fold (*F*). Following along the Carboniferous outcrop we find the dip of the strata steadily but slowly increasing, until, at the highest point, it reaches about 20°. From the summit of this hill the strata slope off to the northward, rapidly diminishing in dip. In regular succession we find the Permian (*e*), Triassic (*f*), Jurassic (*g*), and Cretaceous (*h*) beds. The hill showing the highest outcrop of Carboniferous is located on the central axis of the anticlinal *B*. It must be remembered that neither of these two sections cut this fold at right angles to its trend, and that in reality, therefore, the inclination of strata is steeper than here represented.

Section XI begins with beds of the Sweetwater Group, covering the older formations. The first exposure we find of older strata consists of Permian beds (*e*) which appear superimposed upon the massive blue Carboniferous limestones (*d*). At the highest point of this latter we notice a slight flexure of the strata. Dipping to the westward originally at an angle of 18° to 20°, they suddenly dip to the east 12° for a short distance, and then resume their former position. Erosion and perhaps breaking of the strata has exposed the Subcarboniferous Group, which we find resting directly against the younger granites. Along this line of section we cut one of the hills composed of this material. It is an isolated one, as is shown by the appearance of Carboniferous beds east of it. A little farther on everything is once more covered by Tertiary deposits. In both sections the Prozoic granites (*P*) have been indicated as existing, but not yet reaching the surface.

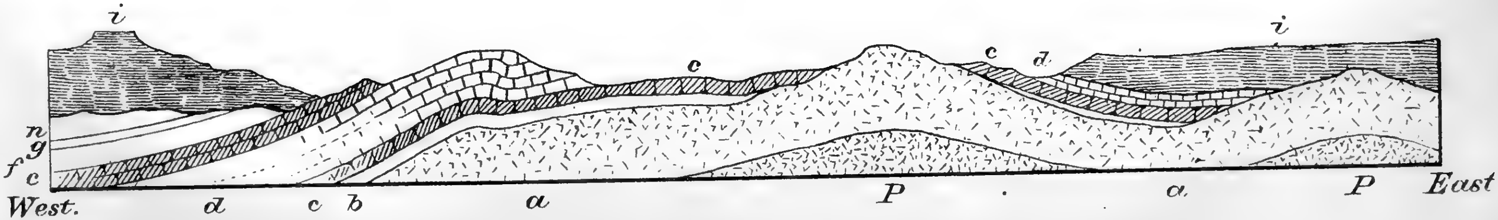
If we follow the line of the anticlinal (*A*) we will find it to lead us to the Palæozoic exposures west of the first masses of metamorphic granite in the Sweetwater Hills. In a similar manner the second one (*B*) points toward the region of disturbance east of Elkhorn Gap.

At the point first mentioned the Carboniferous strata occupy a very prominent position. They form narrow sharp ridges dipping to the south at an angle of about 70°. Several small cañons lead through these ridges into the slopes of the Sweetwater Valley. Here, as well as elsewhere, the massive blue limestones are entirely conformable with the older beds. So far as could be determined without horizontal measurement, the thickness of the beds here amounts to about 1,600 feet. In lithological character the rocks are exactly the same as east of the Wind River Range. Only for a short distance does this outcrop of Carboniferous beds extend. Probably the beds do not reach sufficiently high up on the northern side to protrude through the Tertiary beds. On the south side they rapidly lose their dip and sink out of sight.

East of Elkhorn Gap the Carboniferous limestones again appear. An isolated rock, about 200 feet in height first indicates their presence. We found it so steep as to be inaccessible. Strata standing on end have given rise to its formation. From there eastward the limestones follow a narrow line of outcrop. We find that directly north of this series of Carboniferous strata a small quantity of granite occurs, which soon disappears, however. Tracing the beds along their strike we observe that the limestones make a sudden bend toward the southeast. At this point a heavier mass of granite jutting up on the north side has caused a complete overturn of the strata, causing an S-shaped fold. The flexure of the strata is such as to produce, on the present surface, a steady dip to the northward. Near the hillside everything is obscured by drift and timber, so that but little can be learned as to the southern continuation of this interesting point. The only indications, indeed, that can be ob-



Section 10.



Section 11.

tained at all, are derived from the red color of the Triassic Group. While discussing this, a section will be given which cuts this region.

Directly east of Whiskey Gap the Carboniferous Group reaches the greatest development and most prominent position in our district. Standing on end, or showing a dip of 80° to 85° to the south and southwest, the strata are first found low down, but soon make a turn to the southeast and occupy the summit of the hills. Their mode of weathering and the position of the strata give the Seminole Hills a very characteristic appearance. The white, blue, and yellow dolomites and limestones of the Carboniferous formation produce high, almost vertical, walls, separated by narrow gullies which are filled with loose *débris*. Retaining a strike a little south of east, we follow the Carboniferous Group throughout the Seminole Hills to Sandy Creek Pass. Retaining a very steep southerly dip, it is gradually crowded toward that direction by the increasing bulk of the granites directly to the north. Inclining with the strata, but diminishing in dip, are younger sedimentary beds.

Wherever we find the Carboniferous Group represented in the region to which this chapter is devoted, we found that the limestones were thoroughly impregnated with siliceous matter. As in the Wind River district, so here too, there are a number of varieties of quartz to be seen, occurring in the form of concretions, geodes, and small seams. All the fossils, which are the same as those found to the northeast, are silicified and very poorly preserved. Crinoids make an exception as to their composition. In the Seminole Hills the thickness of the Carboniferous Group appears to be about 2,100 to 2,200 feet, perhaps a little more. The position it occupies renders it difficult to make an accurate estimate.

Permian Group.

About this group but very little is to be said. It is analogous to the occurrence on Twin Creek, which has been described in the preceding chapter. On the upper portions of the Sweetwater it is entirely hidden by Tertiary beds, and first appears in the Sweetwater Hills. In connection with the Carboniferous outcrop shown in Section XI the Permian strata are found in the low valley directly west of the main mass of limestones. At that point they are composed of gray, greenish, and pink sandstones, with some shales, and show indistinct remains of plants. I did not succeed, much to my regret, in obtaining even a single specimen that could be identified. Here the thickness of the group is rendered doubtful by the direct superposition of beds belonging to the Sweetwater Group. Farther east the Permian occupies a position directly above the blue limestones, as heretofore, and takes part in all the flexures and plications that have been described as occurring in connection therewith. A maximum thickness of nearly 300 feet is reached at some of the more easterly localities. Farther west the thickness diminishes to less than 200 feet.

MESOZOIC FORMATIONS.

TRIAS.

Traveling downstream in the Sweetwater region, we meet with the first outcrop of Triassic beds at the western end of the Sweetwater Hills. There they are overlying Carboniferous strata conformably, but soon disappear. sinking down low toward the east, while westward they are covered by Tertiary beds. As usual, they show the typical red sandstones and shales, amounting in thickness to about 600 feet. From Section

VII their relative position may be learned. We do not meet with them again until we have crossed Elkhorn Gap, about 15 miles eastward. At this locality we have occasion to observe very clearly the upper white and pink sandstones which close the group. Its thickness amounts to about 250 feet, including the light shales and marls.

The thickness of the total group is about 650 to 700 feet. Here we have arrived at the locality of maximum plication of the strata. It manifests itself in an oval quaquaversal arrangement and in the reversion of the order of succession. This quaquaversal is not the result of an anticlinal upheaval alone, but is due to the anticlinal fold produced by a lateral compression of the beds. Erosion has removed the apex of the flexure, leaving what German geologists term an "airsaddle" (*Luftsattel*). Section XII cuts through this point in a direction about N. 45° E., and will explain the grouping of the various formations implicated in the movement.

Advancing from the northeast, we pass over the strata of the Sweetwater Group (*l*), until we find rising before us a wall of red quartzite (*c*). This stands so nearly vertical that it is impossible to determine toward which direction it inclines. Crossing this we find the series of Carboniferous groups (*d*, *e*, *f*) dipping toward the northeast. Continuing farther, in a straight line, we cross successively: Trias, Jura, Dakota, Jura, Trias, Jura, Dakota, Colorado. From that point drift obscures all outcrops, with the exception of one red spot higher up, indicating Trias. Examining the dips, we find the series of beds just enumerated dipping uniformly to the northeast at angles increasing from 35° to 50°. The last outcrop of Dakota to the southwest stands vertical, as do the Colorado shales. It could not be determined how thick the last named were, owing to an accumulation of drift. A section at right angles to the one we have given would cut Carboniferous, Trias, Jura, Dakota, Jura, Trias, Carboniferous. As the axis of elevation is not vertical, the Dakota and Jura would not be cut at the northwestern end of this latter section. As in the previous one, so here too do we find the dip arranged in conformity with the slanting quaquaversal structure.

In the section only such portions the position of which could be definitely established have been directly indicated, the remaining continuation having been given, as supposed to exist, in broken lines. We find that from the northwest the strata have been overturned. Descending from the highest Carboniferous point toward the southwest, we pass successively over the edges of one group after the other. Reaching the Dakota, we find that this is doubled. Here, then, we have a synclinal fold immediately succeeded by an anticlinal. While both are due to the same cause, namely lateral pressure, the horizontal dimensions of the latter exceed those of the former. As soon as we have passed this doubled portion we again reach Jurassic and then Triassic strata. Within the latter we reach the apex of the slanting fold. Beyond this the order of succession is again reversed until we reach the limit to which our examinations of the surface can extend. Colorado shales, standing on end, are the last group that appears clearly in this section. Drift obscures all the remaining portions. In the section, broken lines, indicating the various formations, have been extended, so as to show a connection with the metamorphic granite of the ridge southward. This has been done because we observe a small Triassic outcrop on the north slope of the ridge, and because farther east we find the beds higher up. It will be seen that a line dividing the completed folds (*p q*) runs upward at a considerable angle. To this is due the fact that the Colorado shales are eliminated from the first synclinal fold which doubles

the Dakota sandstones. The line *n o* has been drawn to indicate the possible limits of the metamorphic granite (*b*). North of the sedimentary formations the section contains a body of granite (*a*) which does not appear on the surface along that line, but crops out, holding the same relative position only a very short distance farther west.

This section presents the most interesting case of plication which we observed in our district. I attribute it to the influence of the anticlinal upheaval which has previously been alluded to, and is marked B on the sections. The character of this section is in perfect accordance with the dynamic manifestations which we are accustomed to see in this region, and fully coincides in structure with the "oval quaquaversals" so frequently exhibited in this section of country. The overturn of the strata is an interesting and important feature. It is very much to be regretted that the thick Tertiary beds to the north prevent any outcrops in that direction, because the position of the Palæozoic groups there must necessarily afford a large amount of information upon the nature and extent of the forces which produced these and other plications.

On the Sweetwater Hills the Triassic beds are exposed again a short distance west of Whiskey Gap. They there retain the same relative position as heretofore.

At Whiskey Gap we find the continuation of the Triassic beds. They appear along a line curving first north, then east, and finally southeast. A prominent bluff is formed by the superimposed Jurassic strata, below which the "red beds" form a steep northerly slope, bare of vegetation. An excellent opportunity was here afforded to search the strata for fossils, but all our effort in that direction resulted merely in obtaining some fucoidal plates which were very poorly preserved. At this locality the division between the lower red shales and sandstones and the upper lighter ones is very marked. The latter group contains white, yellow, and pink sandstones, heavily bedded and interstratified with thin layers of pink and light-green shales. Below that follows the series of massive, highly argillaceous red sandstones. These overlie thick beds of bright red shale, containing interstrata of yellow, pink, white, and bluish dolomites. Varying from 2 inches to 2 feet in thickness, these hard beds produce slight terraces in the slopes occupied by the shales.

In every respect, except in the absence of fossils, the red beds of this region closely resemble the *Keuper Group* of the South European Trias. The "*marnes irisées*" of the French and "*Bunte Mergel*" of German geologists agree closely. Although this group in Europe shows a great paucity of fossils, some typical genera occur which we fail to find in what we regard as the Triassic beds of the Rocky Mountains. The thickness of the formation east of Whiskey Gap may be regarded as very near 1,000 feet.

Curving with the Palæozoic series, the red beds sweep around the western base of the Seminole Hills, and disappear altogether from the northern slope. Skirting the border of the hills on the south side, they gradually sink down and disappear in the vicinity of Sandy Creek Pass. There some slight local disturbances, probably nothing more than unimportant faults, have caused a change of the dip, which is generally to the southward.

JURA.

Varying but slightly in character from the Jurassic beds east of the Wind River Range, we find the same formation exposed on the Sweetwater drainage. Essentially the arrangement of strata is the same,

changing a little in relative thicknesses, however. We first met with Jurassic limestones in the western portion of the Sweetwater Hills. After but a short line of exposure, during which they remain conformable with the underlying red beds, they are hidden by younger deposits. Again they appear east of Elkhorn Gap, taking part in the folding which is represented by Section XII. Innumerable fossils were found at this locality, limited unfortunately to *Belemnites*, *Camptonectes*, *Pecten*, and *Gryphæa*. Several specimens of the first-named genus were collected which closely resemble *B. brevis* of the European Jura. At the eastern end of the Seminole Hills, Jurassic beds occupy a prominent position. Resisting erosion more effectually than either the older Triassic or younger Cretaceous rocks, they form a conspicuous line of sharp, narrow ridges. In their course, these trend first toward the east, then turn south and flank the termination of the hills. Passing over to the southern slope, they are soon lost under the accumulation of younger formations. In the vicinity of Whiskey Gap an increase of the total thickness may be observed over that seen farther northwest. The entire series of beds here measures about 260 to 300 feet.

Judging from the character of the strata composing the formation, there is no doubt but that the Jurassic deposits of our district at one time formed a connected sheet. Now they are broken, through the agency of stratigraphical disturbances, and are exposed only at favorable localities. We may assume, however, that unless removed by early erosion, the same beds extend through under the extensive series of Tertiary deposits which have accumulated in the region of the Sweetwater River.

CRETACEOUS.

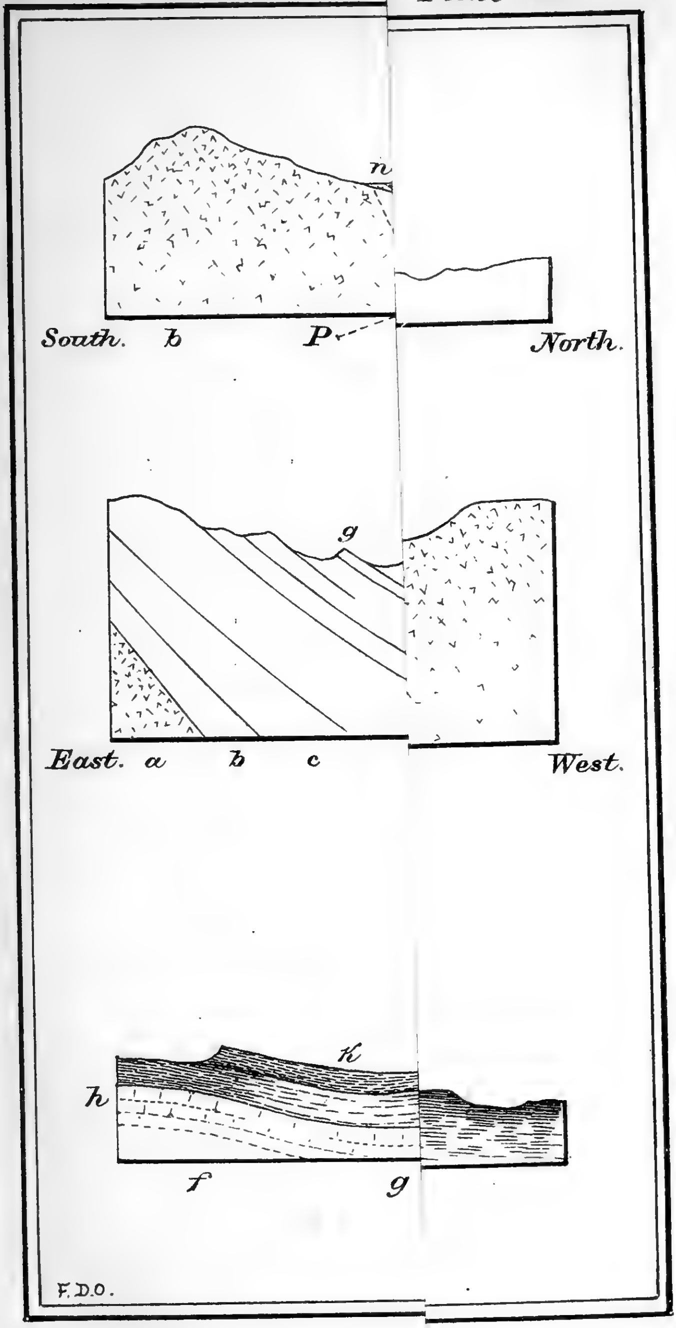
Dakota Group.

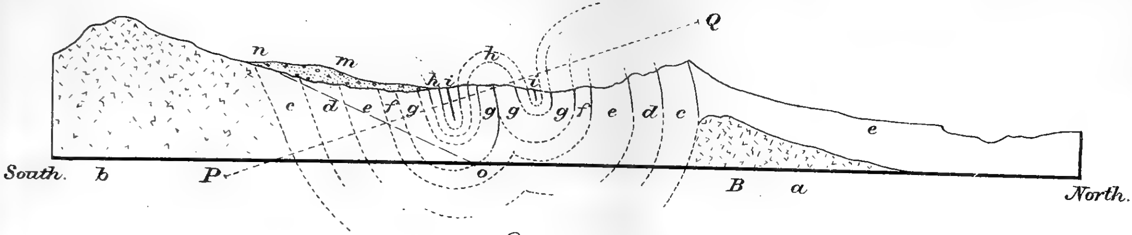
Cretaceous groups are represented very sparingly in the region of the Sweetwater. We find the lower sandstones of the Dakota Group protruding from under Tertiary deposits at the northern portion of the Sweetwater Hills. The characteristic yellow and white color, as well as the features of weathering, permit it readily to be recognized. East of Elkhorn Gap we again find it, very much folded by the plications occurring there. Section XII illustrates the position of the group. At one point we find it directly doubled, forming a synclinal fold, the horizontal extent of which is equal to zero. The two sides are closely joined in such a way as to change the character of its usual appearance.

In Whiskey Gap the members of this group occupy a very interesting position. Curving in the same direction and manner as the older formations heretofore described, the strata curve around the western base of the Seminole Hills with a partiversal dip. From indications elsewhere obtained we find that a short distance farther west they take part in an anticlinal upheaval. In order to make clear the stratigraphical conditions within Whiskey Gap, I have prepared a section cutting across it from east to west and one from north to south.

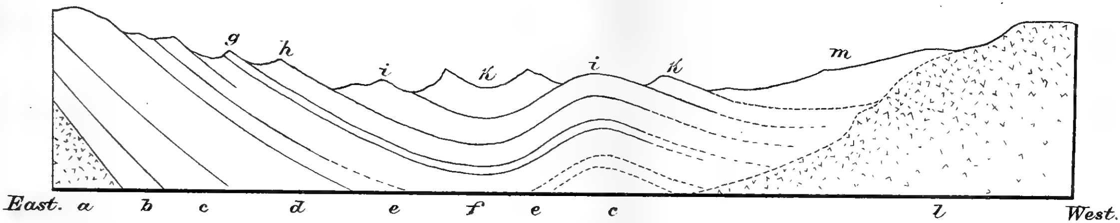
Section XIII commences at its eastern end, near the summit of the Seminole Hills, and extends across the gap to the eastern termination of the Sweetwater Hills. Beginning with the Palæozoic series, we find that the various formations along this line show a westerly dip. Resting upon metamorphic granite (*a*) we have the Silurian beds (*b*), which, in turn, are covered by Subcarboniferous (*c*). Above this occur the massive blue limestones (*d*), which, farther east occupy the highest portions

U.S. Geological Su[rvey] Plate IV.

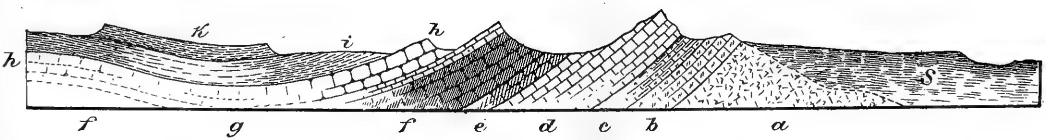




Section 12.



Section 13.



Section 14.

F.D.O.

of the hills; they are succeeded by Permian (*e*) and Triassic strata (*f*). Jurassic beds (*g*) form a prominent, sharp ridge directly underlying the Dakota Group (*h*). This latter dips at an angle of very nearly 45°. Yellow and white sandstones, gray and brown shales, and beds of argillaceous sandstone compose the series at this locality. Its thickness is about 700 feet. Overlying the Dakota we find Colorado shales (*i*), forming low bluffs which trend parallel to the others. Fox Hills (*k*) is the youngest group cut by this section. We observe that a short synclinal fold is very apparent here, followed immediately by an anticlinal (*c*). From subsequent examinations we found that at this point we have the northern termination of a great anticlinal fold running north and south and ending near Rawlings Springs. In Chapter IV this will be more fully discussed. On the western side of the anticlinal the Fox Hills beds again dip eastward and disappear under a large mass of drift (*m*), which covers the end of the Sweetwater Hills. Exactly in what relation the sedimentary beds stand to the granite (*l*) of these hills could not be determined, as none of the exposures afforded any evidence upon this point. In the section I have indicated the various groups as following in a diminishing ratio the flexures observed on the surface. Farther south we have evidence which justifies the representation of such an arrangement. Their terminations to the westward are necessarily left doubtful.

Section XIV runs at approximately right angles to the preceding one within the gap. At its southern end we see the last slope of the anticlinal (*C*), after which the strata resume a southerly dip. Going northward we cross one formation after the other in regular succession. The first prominent ridge is formed by Jurassic beds (*g*), and the second by Carboniferous limestone (*d*). North of the latter the Silurian quartzites appear in a narrow band. No granite reaches the surface along the line of this section. As it appears, however, a few miles farther east, it is introduced in the section (*a*) as covered partly by the quartzites (*b*) and partly by the Tertiary Sweetwater beds (S).

On first sight the arrangement of strata in the immediate vicinity of Whiskey Gap is very puzzling, but as soon as the existence of the anticlinal fold (*C*) is recognized the entire system becomes very clear.

Colorado Group.

But two localities are to be recorded where shales of the Colorado Group appear within the region. The first is near Elkhorn Gap, the second in Whiskey Gap. At the latter place the shales are dark gray, finely laminated, and contain numerous fragments of *Inoceramus* and *Ostrea*. Their thickness is about 650 to 700 feet. Within the gap they mostly occupy depressions, running parallel to the strike of the strata. From Sections XIII and XIV, their position, as compared to that of other groups, may be seen. In the structure of the anticlinal (*C*) they are of considerable importance, and will be treated of at greater length in the succeeding chapter.

Fox Hills Group.

The only point where these were observed is in Whiskey Gap. Forming sharp, low ridges, they participate in the stratigraphical disturbances there occurring. Owing to the numerous changes of position to which they were subjected, it is rather difficult to estimate their total thickness. It is near 1,000 feet, and seems to increase toward the south.

CENOZOIC FORMATIONS.

TERTIARY.

On the southern drainage of the Sweetwater we find a number of Tertiary groups. They shall not be considered in this chapter, however, as they form but a portion of a very extended series. To this will be devoted the greater part of the fourth chapter. For this reason I shall not attempt a discussion of any of these groups here, as it would necessarily be but fragmentary. Two groups, however, occupy very extensive areas in this region—the Sweetwater Group and some younger beds—which will be fully treated of. Although interesting to the palæontologist, and in some of its features to the geologist, this series nevertheless is a great aggravation. Its great horizontal extent obscures many regions of the utmost interest as regards stratigraphy, consequently a large portion of the structure of the country adjoining the Sweetwater can be established merely by insufficient data. Fortunately, the Tertiary beds have been removed at some points, and these afford information without which the correlations of older formations would remain very obscure.

SWEETWATER GROUP.

A very striking aspect is presented in the vicinity of the Sweetwater by the enormous deposits of clays, sands, marls, and conglomerates. Frémont in passing through that region noticed them and comments upon them. Dr. Hayden visited this region in 1870, and describes the Sweetwater Group as "brown, indurated sands"; * * * "among them are impure seams of lignite or carbonaceous clay, with layers of coarse sandstone or an aggregate of particles of quartz." Evidently that section of country running parallel with the river was at one time the object of very extensive erosion. Into the basin formed thereby a series of Tertiary beds was deposited. Subsequent removal along nearly the same line afforded an opportunity for still younger beds to be deposited. Finally, or rather during the latter process of sedimentation, large masses of irregular drift were scattered all along the borders of this second lake. Near the Wind River Mountains this is of such a character that it can scarcely have been deposited in any other manner than by the action of moving ice.

On the northern edge of the Sweetwater Plateau we have occasion to observe the best outcrops of the Sweetwater Group. Overlying the beds which I have described as Wasatch we find an extensive series of brown, yellow, and white arenaceous marls and clays. Some sandstones, though not showing clearly defined stratification, complete the series. Higher up, toward the summit of the plateau edge, the sands and some conglomerates of yellow color become prevalent. On this side the loosely cemented material is very easily eroded, and forms steep, deeply furrowed slopes. All along the northern edge of the plateau the same beds can be traced, dipping very gently toward the east. This inclination is so small that it is not perceptible unless a large face be exposed. We find on the same line the contact of the Sweetwater Group with the older sedimentary groups, and observe the two to be unconformable. Reaching the Wasatch, which is the youngest Tertiary deposit I recognized on the Wind River drainage, we find that this shows a steady dip of about 2° to the northeastward. Noticing other formations, older, we find that this dip is due to the same influences which caused the elevation of the Wind River Range and the subsequent formation of the Sheep Mountain anticlinal. The angle of unconformability between the Wasatch

and the Sweetwater beds is not over 30′ to 1°, but it can distinctly be recognized.

While the northern termination of the group is thus clearly defined, the southern is subject to greater variations. We meet with the most westerly outcrops directly south of the area of metalliferous schists. A high hill, Yellow Butte, upon which our station 21 was located, forms a prominent landmark of that region. Its base is composed of older Tertiary groups, but the upper portions on the northern slope show the indurated clays and arenaceous marls that are typical of the Sweetwater Group. I regard this as the first appearance of the group toward the southwest. Going toward the eastward from that point we find a series of hills formed by it, south and southwest of Saint Mary's Ranch. East of the station the high hills south of the river, which here take the name of Sweetwater Hills, are composed of strata belonging to the same group. In this region it overlies carboniferous limestones. The strata, so far as they can be distinguished, are very nearly horizontal. As we approach that portion of the Sweetwater Hills which is composed mainly of granite, we find the beds of this group confining themselves mainly to the northern side. Near the outcrop of older sedimentary strata some prominent bluffs are still formed by it, but they soon disappear from the south side. In Elkhorn Gap the central butte, which has been mentioned in previous pages, is formed by strata belonging to the same series. They lie perfectly horizontally, and are eroded into various picturesque forms. All along the northern slope of the hills the outcrops of the Sweetwater Group are obscured by extensive accumulations of loose drift. North of the Seminole Hills the strata appear again in some high bluffs west of Sandy Creek, and then pass out of our district.

Erosion has wrought very great changes in the distribution as well as in the vertical dimensions of this group. Perhaps the best exposures illustrating the latter may be obtained along the northern edge of the Sweetwater Plateau. From what was seen there, I should place the thickness of the series at 1,200 to 1,400 feet. No locality shows more completely the stupendous effects of erosion than this one. There is but little doubt that the beds composing the group at one time extended far beyond their present limits, but they have been removed and utilized in making up younger deposits. At the present time, therefore, we find exposed the older sedimentary formations from the Wasatch downward. As seen from a distance, I suspect the existence of some Green River strata in the extreme northeastern portion of our district. As our work did not carry us into this region, however, owing to a lack of time, I cannot be positive on this subject. To the southward we find the Sweetwater Group overlying various groups, beginning with the Green River group and descending from that in the geological scale.

Along the northern portion of the plateau a slight southerly dip of the strata can be observed, varying from 2° to 4°. Dr. Hayden noticed this feature in 1870, and regards it as due to the "last movements subsequent to their deposition." This occurrence will be further discussed below. Approaching toward the Sweetwater River from either north or south, we observe that the Pliocene beds entirely cover the Sweetwater Group. It is exposed only in some of the deeper gulches at localities from which it had not been removed by previous erosion. Dr. Hayden thus graphically describes the geological history of this valley:*

"All the unchanged formations, from the lignite Tertiary down to the massive feldspathic granites, have been worn away, leaving the granites scattered over the valley

* Rep. U. S. Geol. Surv., 1870, p. 29.

in the isolated ridges. At that time there was a fresh-water lake which occupied the entire valley, much as Salt Lake once occupied the great basin, concealing most of the granite ridges, while others rose above the water like islands. Then was deposited what might be called the Sweetwater Group, or perhaps a series of beds identical with the upper portion of the Wind River deposits. These were scooped out again in time, and the Pliocene marls and sands were deposited; and then again there was another scooping out of the valley, and finally a covering the hills with drift."

As regards the geological position of this local deposit, there may appear to be some doubt. From what I have seen of it, I consider it younger than the Green River Group. This agrees with the views held by Dr. Hayden, Cope, and Comstock. At this place no more shall be said on the subject, because the relative positions of Tertiary groups will be more fully discussed in Chapter IV.

Pliocene.

Filling the excavation produced by the second period of erosion of the Sweetwater beds we find an extensive series of Pliocene deposits. Their greatest development was observed near the eastern termination of our district, decreasing as we proceed to the westward. Near the base of this Pliocene deposit we find a very loosely aggregated sandstone, almost partaking of the character of a conglomerate. It is light gray and yellowish, easily decomposing. Locally a few thin strata of yellow or gray more compact sandstone may be observed. Above this follows a succession of light marls and indurated clays. Usually these are either very light yellow or white, but pink and greenish beds are not wanting. Toward the eastern termination of the group the strata become highly siliceous. Thoroughly permeated by silica, the clays become very hard and brittle. The former occurs also in the shape of narrow veins, concretions, and even strata. Chalcedony and flint are the two main varieties. Near the northern edge of the Sweetwater Plateau we perceive isolated, table-shaped bluffs rising above the general level. They are of dazzling white color, and are composed of soft, partly arenaceous marls. From this edge very even ridges slope gently down toward the Sweetwater. On the south side the same feature may be observed. Starting from the Sweetwater and Seminole Hills the ridges trend north and south, are very regular in form, and are composed of very nearly horizontal strata. Between Sandy Creek and the Sweetwater we find the Pliocene Group cut into sharp, prominent forms, due in part to the large amount of silica it contains. This produces angular forms upon weathering, while the soft marls and sands show gently-rounded slopes. Near the northern slope of the hills extensive deposits of loose drift cover the strata, totally obscuring all junction-lines.

For a considerable distance the Pliocene beds form the northern rim of the plateau, until they are crowded from this position by the remaining portions of the Sweetwater Group toward the west. Along a north and south line drawn about four or five miles east of Saint Mary's Station we may regard their western limits as being located. Within the granitic area south of the river we find them directly superimposed in snow-white masses upon the Carboniferous limestones. From there eastward they are confined within the Sweetwater Valley. Their horizontal distribution is entirely dependent upon the area of erosion within the Sweetwater Group. Along the slope of the plateau the Pliocene strata participate in the slight southerly dip which has been recorded as existing in the Sweetwater Group. It amounts from 1° to 4°.

In some of the upper beds of this series Dr. Hayden has found some very interesting mammalian remains, which place them on a parallel

with the Niobrara Group. We discovered several localities where such fossils were found, but they were too much weathered to be recognizable. It appears that at some places the bones are impregnated with silica, which renders their preservation almost a matter of course. Wherever this is not the case, however, good specimens can only be obtained by excavating. The identification of the fossils obtained is such as to leave no room for doubt as to the position of these beds.

An interesting feature in connection with this series was observed near Agate Lakes, directly north of the Sweetwater. Innumerable moss-agates are strewn all over the surface. Some of them are very fine and cut admirably. So far as we could observe, all of them are water-worn, occurring in the form of small pebbles. The area upon which these agates may be found measures about 6 square miles. We endeavored to find the original locality from which they came, but failed to do this to our satisfaction. At some places we observed narrow, irregular seams of quartz or milky opal running parallel with the strata of white marls. These contain dendritic inclusions of manganese, forming moss-agates. In no instance, however, was the mineralogical character of the quartz perfectly identical with that observed in the pebbles. Northeast of the locality at which we collected the agates we found a number of beds very highly siliceous, which showed similar forms in the quartz. They extended for a considerable distance. I am of the opinion that the numerous agates strewn over the ground were derived from the western continuation of the higher portions of these beds, which are entirely removed. The quartz which appears so plentifully in this region must have been held in solution, judging from the character of its distribution. Percolating through the loose marls and sands, the siliceous solution deposited quartz in narrow seams and in layers parallel to the stratification. Most likely this occurred while the silica was in a hydrous condition. It is an accepted fact that the "moss" in agates is but the result of impeded crystallization. Within this gelatinous quartz, then, this incomplete process may have gone on until eventually the inclosing material became rigid. During our examinations of this region we saw such enormous quantities of such material that the sum of our observations suggested this method of genesis.

It is evident that the thickness of a group deposited in such a manner as this Pliocene series must vary considerably. The best exposures were obtained low down on the Sweetwater and along the northern edge of the plateau. From what was seen at these localities, I estimate the maximum thickness of the Pliocene strata at 700 to 900 feet. Toward the west they grow thinner, until finally they pinch out altogether.

Wyoming conglomerate.

This term has been used by Emmons and Hague to designate the wide-spread conglomeritic accumulations of drift which may be assigned to the Pliocene period. It is entirely structureless, and composed of the most varying material. Essentially it may be regarded as the product of all formations existing within a given area. During the last era of extensive inundations it was deposited at the most convenient localities. Along the entire northern slope of the Sweetwater and Seminole Hills we find enormous deposits of this material. No structure whatever can be observed there, and the whole mass forms merely a huge cover of erratic bowlders. Their size varies somewhat, but does not reach any considerable dimensions. We find the narrow gullies running down from the hillsides cut into this conglomerate, and the tops of the ridges are

covered by it for some distance. Its presence is so marked a feature in this region that it cannot be overlooked. With regard to its age, I consider the period of deposition as synchronous with that of the younger portions of the Pliocene marls and shales. It is found near the edges of the ancient lake, and was probably carried there by the waters draining into the former. It must not be mistaken for the glacial drift which occurs in the same region. The relative positions alone of these two deposits will easily determine their character.

ERUPTIVES.

No eruptives whatever are found in the area of which this chapter treats, except those basaltic dikes which are inclosed by Prozoic granites. Their general strike is northeast and southwest. In width they vary from a few feet to several hundred. This occurrence, both in the Granite Hills and in the granitic outcrops west of the Sweetwater Hills, presents an instance of very old eruptives. Carboniferous and younger strata were observed in direct contact with the granites as well as with the dikes, but in no instance did the latter penetrate farther than the granites. In Scotland a number of basaltic outcrops occur which are regarded as being of Carboniferous age. Here we have an instance, however, of still greater age. From a distance the dikes appear as prominent black bands, generally closely conforming with the surface of the granites, but sometimes rising above it as the adjoining rocks have been removed by erosion and disintegration.

POST-TERTIARY EROSION.

Since the cessation of stratified deposition a large amount of erosion has shaped the present form of the Sweetwater region. Toward the north great masses of material have been carried off in a northeasterly direction, leaving the steep wall of the Sweetwater Plateau. The central portion of the Tertiary groups has largely been cut away in a direction of west to east. This has produced the "trough" in which we now find the river. From the southward slope of the plateau-beds, at least several hundred feet in thickness have been removed from over a considerable area. Isolated, table-topped buttes, horizontally stratified, indicate the former vertical extent of the Pliocene beds. Gulches, ravines, and valleys have been carved into the easily-eroded material, and large portions of this have been transported eastward. At a rough estimate, we may say that fully one-fourth of the Pliocene beds north of the river has been carried away. Toward the south we notice extensive erosion also. It is most prominent near the western termination of the Tertiary groups. Hundreds of feet in thickness have here been cut away, until the active waters found some stratum which arrested their work of destruction. Long, narrow ridges are produced by a former system of ample parallel drainage. Deep gulches, now dry, then contained rushing streams of water. From the condition in which we find many of these ancient water-courses, we may infer that the influx of large streams ceased within a comparatively short space of time after the period at which they had attained their maximum proportions. The old beds show a steep fall and but little accumulation of drift. Both of these characteristics would be reversed had the quantities of water diminished at a very slow ratio.

From the slopes of the Sweetwater and Seminole Hills, as well as from that of the plateau, large quantities of drift were carried toward

the river. We observe in consequence, firstly, a widening of the immediate river bottom, and, secondly, an accumulation of fine drift near it. Wherever the Sweetwater passes through some narrow gap in the lower half of its course, we generally notice a decided widening of the bottom land immediately above the more restricted passage. This is due to the accumulation of drift, which tended to equalize the level at such points. At the localities where this occurs we will see that the river follows a serpentine course.

ANCIENT GLACIERS.

Between Elkhorn and Whiskey Gaps, on the northern slope of the hills, the most striking remains of old glaciers were found. Directly east of the first-named depression we find extensive deposits of drift about half-way up the hills. They do not extend far down, however. A little farther east, on a creek which we named Glacier Creek, there are extensive moraines. Starting near the summit of the granitic hills, the glacier moved down a narrow valley toward the north, receiving additional masses of ice from branches on either side. Spreading in an oval valley between the outcropping sedimentary beds and the metamorphics, the glacier covered an area of about two square miles. Finding its way through a narrow gap, the ice moved down in the valley of Glacier Creek, depositing very finely developed lateral moraines. These are arranged in several parallel rows, showing that a number of small glaciers must have passed down the valley. In height they amount to about 30 feet here. Lower down on the creek they become higher, until finally a huge mass of bowlders and drift announces the termination of the glacier. All the slopes and ridges of this immediate vicinity are covered with glacial drift. It is here usually distributed without any order of arrangement, but in the valleys the moraines are well developed. For a considerable distance eastward we find a continuation of the same occurrences. So far as we could determine, the moraines do not extend beyond the immediate base of the hills, but wide, grassy valleys indicate the action of the waters formerly flowing off from the glaciers. These latter deposited a large amount of silt and soil, which now form the meadow grounds.

At the northeastern end of the Sweetwater Hills we find a large deposit of drift bowlders that has every appearance of morainal character. It is placed along the upper granitic slope and on benches formed by sedimentary strata. All the beds underlying this drift are entirely obscured, a feature which is indicated in Section XIII. Metamorphic bowlders mainly, and some composed of unchanged sedimentary material, form these moraines. It seems probable that the highest northern slope of this portion of the Sweetwater Hills was at one time covered, to a greater or less extent, by ice. Now it is densely timbered, and but few outcrops of rocks *in situ* can be found. Wherever these are seen they are smooth and rounded. From the higher elevation the ice moved down along the northern slope, filling a number of narrow gulches and finally collecting in a large field on Glacier Creek.

DRIFT.

From what has been said in previous pages, it is evident that a large amount of drift must occur in the Sweetwater region. Besides the Wyoming conglomerate and the glacial deposits, we find that class of transported erratic material known as river drift. It occurs along the river and is scattered in greater or less profusion over the adjacent bluffs. Composed mainly of metamorphic material, a large portion of it has been brought from the region directly at the end of the Wind River Mount-

ains. A secondary class of drift, removed by fluviatile action, is found in the accumulations of sand in the immediate vicinity of the river and in its bed. When found in the latter position it appears frequently as quicksand, rendering the foming of the stream a rather risky undertaking at some places.

SOIL.

Owing to the character of the strata near the river, the majority of drift material in its valley, as well as in those of its tributaries, is found in the form of soil. All along the Sweetwater we find widening portions of the valley which are covered with good soil. A similar state of affairs may be observed in all the broad valleys of the Lower Sweetwater drainage. Along the southward slope of the plateau soil covers the strata and sustains a thriving crop of sage-brush. Professor Comstock has furnished some interesting data in his report* upon the "conservative action" of sagebrush in loose soil. For more detailed information upon the character and probable productiveness of the soil within the Sweetwater region I would refer to the report of Prof. Cyrus Thomas, contained in the report of the United States Geological Survey of Dr. Hayden, 1870. He has made the agricultural resources of the West a special study for a number of years and is qualified to discuss questions of this nature that may at some day prove to be of considerable importance.

SAND DUNES.

On several places along the Sweetwater we observe accumulations of loose sand that owed their present position to the transporting action of wind. They are particularly noticeable in the vicinity of Whiskey Gap. Through the disintegration of the arenaceous marls and loosely-cemented sandstones of the region, large quantities of free sand are scattered over the bluffs and ridges. Westerly winds, which prevail in this section of country, drive the sand before them, until it reaches some permanent obstacle, and is arrested thereby in its progress. Thus we find deep banks of sand several hundred feet long piled up against small granitic outcrops, which have proved to be obstacles in their eastward course. In size they cannot be compared with the sand dunes farther south, but they are due to the same causes, and show the same detail features which there are exhibited on a much grander scale. Sandy Creek Pass leads over a series of sand dunes, which form the eastern termination of the extensive succession of such deposits in the southern area. As this will be considered fully in Chapter IV, this allusion may suffice. Wherever large masses of arenaceous rocks disintegrate, we find local accumulations of sand partaking somewhat of the character of dunes.

RESUMÉ OF THE SWEETWATER REGION.

Within the area to which the third chapter is devoted we observe a number of features of great interest. One of the most prominent is that of the prozoic range. Beginning near the southern end of the Wind River Range, this chain of hills extends for more than eighty miles, sustaining, substantially, but two breaks. While the older or metalliferous schists disappear from view, we find the younger metamorphic rocks occupying a prominent position. A very large proportion of these latter undoubtedly retain their normal position, but a part of them has been subjected to the influence of dynamic forces, and has totally changed its relations to older groups. Taking the prozoic range as a base, we find that it is

*Report Reconnaissance of Northwestern Wyoming, Captain Jones, 1873. Washington, 1874, p. 171.

crossed in the region of its lowest depression by a chain of metamorphic origin. This chain, so far as the evidence collected permits us to speak, is the direct result of an extensive upheaval along a curved line trending from north to south, southeast, and east. It seems surprising at first that neither the older schists nor the prozoic granites are brought to the surface by this extensive action. We must take into consideration, however, the thickness of the youngest metamorphic series, as exhibited farther northwest, and it will be apparent that, unless considerable variations of the vertical dimensions occurred within a comparatively short distance, the older series must remain hidden. Upon recognizing the structure of the hills formed by this southeasterly outcrop of metamorphics, we find in them a stratigraphical arrangement analogous to that of the Wind River Range. Here, as there, we have a predominance of the one side of the anticlinal fold. In other words, the axis of upheaval does not stand vertical. This fact is shown not only by the non-appearance of the repetition of strata on its opposite side, but is indicated by the shape of the area of the metamorphics. Essentially this forms a wedge, showing that the force applied was not an equal one at all points. Were it so, then the outcrop would essentially represent a symmetrical figure.

A second disturbance of metamorphic rocks is due to the more easterly anticlinal upheaval. In this instance the prozoic granites appear to have been affected somewhat thereby. Along a definite line—one coinciding with the longitudinal axis of the fold, we observe an exposure of metamorphic beds which have undoubtedly been raised from their normal position by some locally-acting cause. This fold again may be traced farther to the southeast, forming a curve nearly parallel with the first one. Where appearing in an unmistakable manner at the surface, we find it to be analogous in direction, form, and results with the former. Reconstructing, then, a surface-picture of the region of the Sweetwater prior to the invasion by Tertiary waters, we obtain a result totally differing from that presented to-day. Instead of a general slope to the eastward we find that the region now occupied by the valley was cut by two ridges trending obliquely across it. Of these the western one was the higher. For some distance near the line now occupied by the river existed the divide from which the drainage flowed to the northwest and south. Farther downstream this line shifted toward the southeast and the drainage was mainly to the north. Bare and rugged, as to-day, the Granite Hills rose high above the surrounding country, never, probably, having been entirely under water. This distribution of drainage accounts for the primary erosion we find both to the north and south of the Sweetwater region, more particularly in the former direction. The dividing line was, in all probability, the eastward extension of the axis along which the Wind River Range was elevated. Thus prepared, having much of the sedimentary material removed by erosion, the successive valleys were ready to receive the influx of Tertiary waters. The analogy of the deposits with those found on Wind River indicate that a former connection between the two may have existed. They furthermore substantiate the conclusions drawn from purely stratigraphical occurrences, that the main drainage-connection of this region was to the north and northeast.

So far as the classification of the metamorphics is concerned, which here enter into consideration, we may refer them to the Huronian system.

With regard to sedimentary formations, we may say that their appearance, which in some instances seems contradictory, is fully explained by the movements in which the older rocks have participated. When

first seen, the steady southerly dip of the sedimentary formations of the Sweetwater and Seminole Hills appears to be at total variance with their anticlinal structure. On account of the superincumbency of Tertiary strata the granitic outcrops are most frequently obscured for some distance, and the strata seem totally out of place. By tracing the connection with the two anticlinal folds, however, the necessity of such an arrangement as exhibited becomes clear. Although I do not doubt that a large portion of the sedimentary beds have been removed from the region now occupied by the Sweetwater Group, I consider it highly probable that considerable masses still exist at some depth, which, if exposed, would furnish us with the northern slopes of the anticlinal folds. An interesting case is presented in Section XII, where the sedimentary strata have twice been doubled by lateral pressure. In this instance the granite, which had previously reached the surface by virtue of the westerly anticlinal upheaval, formed an immovable barrier. Between this and the portions elevated by the second fold lay a series of beds which were thus plicated by the force which propelled upward the metamorphic rock first rising into view.

In the presence of the Tertiary groups of the Sweetwater region we have before us a representative of one of the most interesting features of the western country. The comparatively large number of basins which have existed during previous periods, and which do exist at the present time, is a characteristic which is productive of the most surprising variation. Local accumulations of this kind sadly interfere with the accepted standards of geological succession of groups. Palæontological evidence is generally the only resource, in such case, whereby their relative positions can be determined. In the succeeding chapter, I shall have occasion to speak of a number of Tertiary groups, and shall there discuss, in connection with others, the relations of the Sweetwater series. Interesting, as well as instructive, when viewed together with other facts, is the nature and distribution of the Wyoming conglomerate. We know that a number of the Tertiary groups of the west contain varying masses of such material. This is the youngest one within the formation, one spread widely over the country.

Evidence exists in this district that some of the glaciers starting from the Wind River Range extended for very long distances, but as the main portion of the proof is found beyond the Sweetwater drainage, this shall be treated of in the succeeding chapter. In the Sweetwater Hills we find the remains of "extinct" glaciers, which occupied a more or less restricted area. I doubt not but that the surrounding conditions were particularly favorable to their formation at this point, and that they receded, and finally disappeared, in a ratio proportionate to the destruction of those causes that first led to their origin. So far as I have seen the western country, I am persuaded that the glaciation of certain regions was due more directly to local meteorological causes than to the existence of a general glacial epoch. In consequence, I do not believe that the glaciers of the Sweetwater Hills of Wyoming and those of the San Juan mountains in Colorado were formed at the same time, or disappeared synchronously. The general depression of temperature during a certain epoch cannot be denied, but it does not necessarily include the factor of very abundant precipitation, which is the first condition essential to the formation and perpetuation of glaciers.

References have been given in the itinerary and in Chapter I to the climatal conditions and agricultural pursuits of this region. It has often been spoken of with especial reference to these subjects, and the remarks thereupon may prove to afford some additional information.

CHAPTER IV.

GEOLOGY OF THE DEPRESSED SOUTHERN AREA.

GENERAL STRUCTURE.

This entire area comprises more than one-third of our district, extending southward from the Wind River Mountains, the Sweetwater and Seminole Hills, to the southern limits of our work. It is essentially a low bluff country, formed by gentle undulations of the groups composing it. Beginning in the western end, we find bluff succeeding bluff until, in the vicinity of Mount Essex, the general character is slightly changed by the appearance of some eruptive rocks. From there eastward we pass through the low depression which we have called the Shoshone Basin. Farther on we cross the anticlinal fold running from Whiskey Gap to Rawlings Springs. Beyond that, to the eastern limits of our district, the strata dip eastward, forming bluffs with steep western slopes and gentle inclines in the opposite direction. Combined with the east and west flexure of the strata, we observe a steady though slight dip to the southward, indicating a continuation of that observed farther north in the beds of the Sweetwater Group.

Within this entire area we meet with mainly the younger sedimentary formations. Along the anticlinal upheaval above alluded to we find exposures of older groups, but they are confined to a restricted area. The Tertiary formation is well represented, and to its consideration will be devoted the larger portion of this chapter.

METAMORPHICS.

But one outcrop of metamorphic rocks *in situ* was observed in this area. It occurs on and near Rawlings Peak, along the line of the anticlinal uplift. Forming the central mass of this hill, it extends for a short distance to the southward, appearing exposed in rugged masses. On all sides it is soon covered by unchanged sedimentary beds, thus forming the nucleus of a quaquaversal arrangement of strata. The rock is essentially a granitic one, consisting of oligoclase, orthoclase, gray and white quartz, light-green, partly fibrous hornblende, and a small quantity of mica. It might be termed a stratified or stratoid granitic syenite at some points. Its general color is a muddy green, red in some places. No doubt this granite extends northward for a considerable distance, but it does not appear on the surface again. So far as can be seen, the structure of this rock conforms to the anticlinical upheaval by which it has been placed in such a position as to appear upon the surface. Overlying the syenite we find a series of sedimentary formations, which extend for some distance beyond it on three sides.

SILURIAN.

Potsdam Group.

Directly above the metamorphic rocks we observe a series of quartzites and sandstones, dipping off to the west, north, and east. Towards the west, the dip is steep at first, amounting to about 45°, but is somewhat

diminished as it recedes from the central mass. Northward the dip is least, about 10° to 15°, causing the Potsdam strata to disappear under the younger beds. East of the peak, the quartzites first incline steeply, but soon lose their high angle, and are reduced to an inclination of 15° to 18°. Gray, white, and red quartzites and some sandstones compose the series. A good section may be obtained at the southern base of Rawlings Peak. There the thickness of the beds appears to be somewhat over 600 feet.

Calciferous Group.

Above the quartzites and sandstones a thin series of calcareous and dolomitic, partly arenaceous beds may be found. I am in doubt whether they should be referred to this group. No fossils were found in them, and their position cannot be regarded as established. In lithological character they agree with the members of the Calciferous Group elsewhere, but they may represent portions of the Subcarboniferous. Beneath these limestones and dolomites a highly interesting deposit of "red paint" occurs. It is composed of red hematite, exceedingly homogeneous in texture, and free from impurities. Some of it is fibrous, and is usually regarded as nearly chemically pure. A large quarry has been opened, and the hematite has been obtained from it for commercial purposes. Judging from surface indications, its extent is considerable, but the overlying beds rendered it impossible to form any accurate estimate.

CARBONIFEROUS.

Subcarboniferous Group.

A series of yellow and gray, partly arenaceous, magnesian limestones may be referred to this group. They overlie the dolomites which have been regarded as doubtfully Calciferous. An exposure of these strata may be seen on the narrow ridge leading from the "red-paint mine" to the southeast. Here they show a dip of about 30° eastward, veering gradually to northeast. Enormous masses of drift material, which cover all the depressions and many of the ridges in this region, obscures the continuation and vertical development of the strata very much. To the west the same conditions are found to be repeated. Dipping at an angle of 30° to 35° westward, the strata rapidly disappear from sight. Northward the dip is more gentle. An estimate of their thickness, which is rendered more or less inaccurate by the superposition of drift, places the thickness of this group at about 200 to 300 feet. No fossils were found except some indistinct corals.

Carboniferous Group.

After passing the Subcarboniferous strata east of Rawlings Peak, we cross a flat valley about 2 miles in width. Ascending a gently sloping ridge on the eastern side of this depression, we find outcrops of Carboniferous limestones. We have here reached the upper members of the group. Along this line no other exposure is found in the valley. From what we can learn from the occurrences west and north, we are enabled to say that the Carboniferous limestones dip to the eastward throughout, beginning with an angle of about 20°, which decreases to 8° on the ridge mentioned. West of the peak the exposures are more satisfactory, as also north of it. We there meet with the characteristic blue limestones, highly siliceous and massively bedded. Much of the

area over which they were originally exposed is covered by drift, so that but fragmentary information can be obtained. In general arrangement of the succession of strata the group here compares favorably with the outcrops in the Seminole Hills. So far as I could determine, the thickness is diminished, amounting to about 1,400 to 1,600 feet. With the steadily changing dip and the disconnected exposures, it is a difficult matter to reach any accurate estimate of the vertical dimensions. Within these limestones, *Productus*, *Orthis*, and some *Crinoids* were found.

Permian Group.

East of the anticlinal fold, resting directly upon the upper portions of the Carboniferous limestones, some yellow, light-gray, and pink sandstones and shales occur. They closely resemble the Permian beds from adjoining regions. Drift covered all but a small portion of them, so that I nowhere obtained a satisfactory exposure. The thickness of this series will here not much, if any, exceed 150 feet.

TRIAS.

On the eastern side, the Triassic beds are almost entirely hidden by drift, but they were found exposed to the north and west. They occupy but a comparatively small area, being covered partly by drift, partly by the succeeding younger formations. Sandstones and shales of a dark-red color below are followed by massive beds of bright-red shales. Heavy sandstones interstratified with shales, red at first, and changing into pink, yellow, and whitish, close the formation. In the thick beds of shale the characteristic banks of dolomitic composition are found that occur elsewhere in the same horizon. Near the base of the lower sandstones Mr. S. F. Emmons* observed a bed of semi-crystalline limestone, and collected from it a number of specimens of *Natica Lelia*. This is the only genus and species which I know to have been found in the Triassic formation of our district. From the outcrops to the west and north the total thickness of the beds may be regarded as over 600 feet. In stratigraphical arrangement the Triassic beds are conformable to those described above.

JURA.

A series of marls and limestones which occur above the red beds, indicate the presence of the Jurassic formation. We find the arrangement of the strata to be relatively the same as observed at other localities. Dark-gray, partly argillaceous and arenaceous limestones near the base, followed by yellow, gray, and white shales and marls, which contain an occasional interstratum of limestone. Emmons obtained *Camptonectes*, *Belemnites*, *Eumicrotis*, and *Astarte* from the lower limestones; we found *Belemnites* while passing over them. The vertical development of the Jurassic beds has somewhat diminished as compared to occurrences further north. We may regard the thickness as a little over 100 feet

CRETACEOUS.

Within this southern area we have a full development of the Cretaceous formation. While the groups heretofore described owe their surface exposure to a cause that may be regarded as accidental, we can consider the Cretaceous beds as typical for the southeastern portion of our dis-

* Rep. Geol. Expl. 40th Parallel, vol. ii, 1877, p. 162.

trict. It is true that their present prominent position is due, in a measure, to the same disturbances mentioned above, but they occupy an extensive area and reach considerable vertical dimensions. Two districts may be cited as exhibiting groups belonging to the formation. The first is the region north and east of Rawlings Peak; the second, the vicinity of Salt Wells Station on the Union Pacific Railroad. It will be seen that the termination of an anticlinal upheaval, or an "oval quaquaversal," has produced the outcrops at this latter locality. From what has been observed within our district and regions adjoining, both east and west, we can conclude that the entire Cretaceous formation underlies all the younger sedimentary formations, which we shall have occasion to discuss in subjoined pages. It is thoroughly well developed throughout, and wherever it appears shows a singular persistence of typical features within each group.

Dakota Group.

Overlying the strata of Jurassic age we find the conglomeritic sandstones of the Dakota Group. Succeeding are shales, yellow, brown, and gray. The lighter sandstones occurring near the top form a prominent outcrop. It can be traced continuously, dipping conformably with older formations, in three directions. South of Whiskey Gap, the Dakota sandstones disappear, again to be exposed within the gap and along the southwestern and southern slope of the Seminole Hills. No perceptible variation from the thickness as found in the gap can be noticed. Although the Cretaceous groups certainly show a decided amplification toward the south, this is not sufficiently great at this locality to appear prominently. The usual seams of carbonaceous material were found in the lower shales of the group. No fossils were collected, as the outcropping strata were very much weathered, and but few badly preserved plant-remains were seen.

Colorado Group.

In Section XIV the northern exposure of Colorado shales is given. It is there produced, at the southwestern end of Whiskey Gap, by the effect of the north to south anticlinal upheaval. Following the shales in a direction a little east of south, we remain upon their outcrop as produced by the uplift. They show a steady diminishing dip to the eastward. Together with the Dakota Group they form a prominent ridge, trending almost parallel with the longitudinal anticlinal axis, swerving a little to the eastward, however. The shales are very finely laminated, arenaceous in part, and show interstrata of hard calcareous beds or of sandstones. An admixture of ferric oxygen compounds imparts to them a rusty brown color at a few places, but usually they are dark gray, nearly black. Numerous joints and fissures traverse the shales, admitting moisture, and thus giving rise to the only spring of the region, Brown's Spring. In the upper portion of the shales several beds of sandstone set in, forming a sharp cap near the summit of the ridge. It seems that the Colorado shales of this locality are harder than elsewhere, and in many instances resist erosion more effectually than is generally the case. We observe, in connection with this series of outcrops, a feature that can be regarded as characteristic of the group. This consists in the rapid increase of dip upon reaching the upper members of the shales. In this instance the inclination eastward amounts to about 8°, but near the end of the Colorado shales it is increased to about 14°. Whether this be due

to a settling of the strata along the lines of greatest pressure, or to an exfoliation by partial hydration of those portions from which pressure is removed, may remain an open question. Personally, I am inclined to favor the latter proposition, although I am not able to prove it. East of the ridge, the dip of the shales becomes very slight, amounting to about 6°. A wide, flat valley is there excavated by erosion, the drift of which effectually conceals all outcrops. Near the western base of a high bluff east of the valley we obtain the data as to dip. On the western side of the anticlinal we find the same group, but so arranged as to dip in the opposite direction. At the northern end the arch connecting the two is complete and well exposed. It is represented in Section XIII.

Within the shales numerous fragments of *Inoceramus* and *Ostrea congesta* were found wherever they were exposed. Toward the south the group appears to develop considerably in vertical extent. Its maximum thickness may be regarded at 900 feet.

Directly north of Salt Wells we find the other occurrence of Colorado shales in this southern area. It there owes its position to the formation of an anticlinal fold extending to the southwest. We have within our district but the extreme northern portion of this disturbance, which manifests itself in the production of a partiversal arrangement of the strata. At that locality, the oldest group reaching to the surface is that of the Colorado shales. Dakota beds are not exposed until we travel some distance southward. Covered by the Fox Hills series, the shales occupy but a very restricted area, and do not appear again until north of the Sweetwater divide.

Fox Hills Group.

In Whiskey Gap we find the northern termination of the area over which this group is exposed. We there have occasion to observe very clearly the effect of the anticlinal upheaval. The Fox Hills series is broken along the line cut by section XIII; but a short distance northward it is continuous again. Forming a steep synclinal fold, the one portion of the group branches off to the eastward, flanking the southern slope of the Seminole Hills. The other follows a line of outcrop about southeast, dipping a little north of east. This latter owes its position to the anticlinal uplift. We find that the beds of this group form a prominent ridge, rising steeply from the valley directly east of that produced by the upturned Colorado shales. Dipping eastward at an angle of 4° to 6°, the Fox Hills strata gently slope toward the lower country. As usual, the series is here composed of yellow, brown, and grayish, highly arenaceous shales. Beds of sandstone and some of pure argillites occur within them. Toward the top, sandstones of comparatively fine texture set in, forming a cap which protects the underlying shales from total disintegration. Steep slopes characterize the exposed edges of the strata, while the upper sandstones form even or gently-rounded slopes. Some of the highest sandstone strata are very nearly white. Decomposing readily, the shales furnish an excellent supply for the production of alkali. They contain, as well as the Colorado shales, small inclosures and seams of pyrite, which aid rapid chemical changes. Within the beds referable to this group we found numerous fragments of *Inoceramus* and a *Turbonella*. Some small seams of coal occur near the top, but their outcrops were so much obscured that the thickness could not be measured. Along this eastern ridge, the Fox Hills Group reaches a vertical development of about 1,000 to 1,100 feet. A section (Section XV) taken through the anticlinal ridge a short distance north of Rawlings Peak will

explain the relative position of all the groups involved in the movement. On its western side we find a corresponding arrangement of the Fox Hills series, with the exception that the dip is relatively larger, and permits but a smaller area to be exposed. The entire structure of the country west of this anticlinal is exceedingly simple, consisting mainly in a shallow synclinal basin toward the south and an almost unbroken plain to the north.

Section XV runs nearly east and west. We find the anticlinal uplift (*C*) culminating in the elevation of the granitic syenite (*a*) which forms Rawlings Peak. To the eastward, Silurian quartzites (*b*) are resting directly upon it. At the horizon indicated (P) we find the deposit of red paint. Calciferous strata (*c*) occupy a very subordinate position, underlying the Subcarboniferous Group (*d*). Here we begin to notice a decided diminishing of the dips. Massive beds of Carboniferous limestone (*e*) are almost totally covered by loose drift (*o*), and appear only on a small ridge, where the higher members of the group are exposed. Permian beds (*f*) crop out overlying them. Their eastern continuation, the Triassic beds (*g*), and the larger portion of Jurassic strata (*h*) are covered by the drift (*n*) of the second valley. Ascending the ridge eastward, we pass over the members of the Dakota Group (*i*), and reach the Colorado shales (*k*). Following the eastward slope of these beds, which gradually diminish in dip, we find an extensive lake deposit (*m*), extending to the base of the Fox Hill series (*l*). On the western side of the anticlinal we find the same succession, with an increased dip of the beds, however. Here we are enabled to obtain a better section, as but one deposit of drift (*p*) especially interferes with our observations. On this side the Laramie Group (*q*) has been introduced, which covers the Fox Hills.

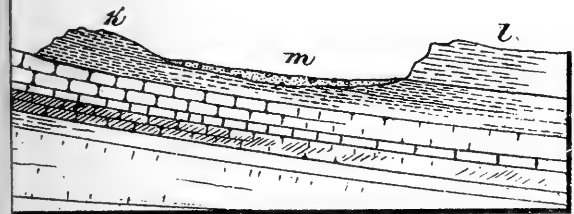
Near Salt Wells the Fox Hills beds are well developed and occupy a very prominent position. A valley of approximately semicircular shape lies directly north of the railroad, bordered entirely by steep, brown bluffs. We find upon examination that these are composed of the characteristic shales and sandstones of the Fox Hills series. Dipping off in every direction, they present a most typical partiversal arrangement of the strata. Near the base they are composed of thinly bedded sandstones. These are followed by yellow and brown shales, more or less arenaceous and micaceous. Above these we find a succession of sandstones and shales, containing carbonaceous strata. A recess in the bluffs is caused by the higher series of shales. The latter are covered by sandstone strata of varying thickness, separated from each other by shales. Some good coal is found in this horizon. Near the top we find massive yellow sandstones overlaid by thin beds of shale and some white sandstones. Throughout the group fragments of *Inoceramus* are very plentiful, but other fossils appear to be rare. On every side the beds are conformably overlaid by strata of the Laramie Group. In speaking of the Tertiary Groups of this region sections will be given showing the arrangement of strata at this locality. The thickness of the Fox Hills Group here is about 1,200 to 1,300 feet.

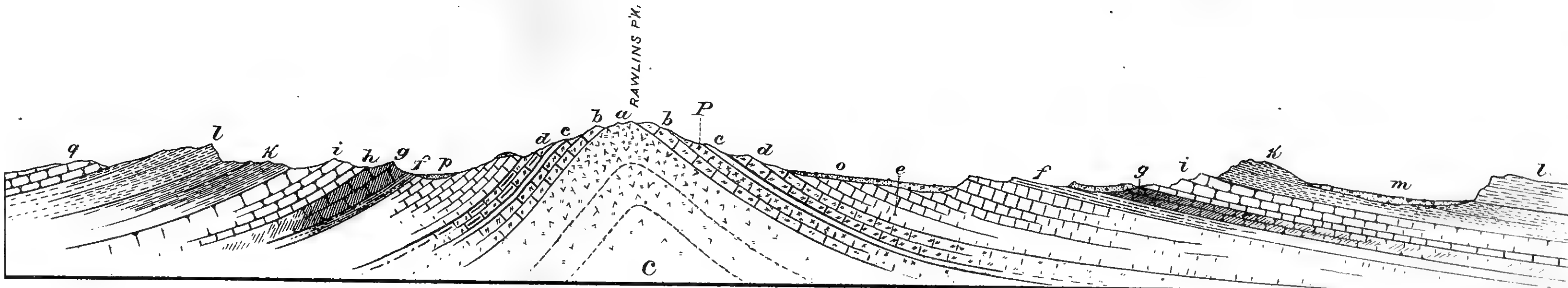
POST-CRETACEOUS.

Laramie Group.

The Laramie Group has a wide distribution in this region. On the west side of the anticlinal we can trace it northward nearly to Whiskey Gap. There the drift obscures all definition as to its termination, but I am inclined to think that it juts directly against the granites of the

Plate V.





Section 15.

Sweetwater Hills. For a considerable distance north no dip is noticeable except that to the west. Near the hills, however, we notice a slight inclination to the southward. It is not more than 2° or 3°, and unless a large area is in view cannot be seen. From there the Laramie beds continue in a westerly direction until hidden by Tertiary beds. From the stratigraphical structure of the entire region we see that this group forms a basin, and, so far as we could determine, the younger strata are conformable thereto. This is the one that, in its surface appearance, has been designated as the Shoshone Basin. As we cross the strike of the Laramie beds, we notice that their dip decreases, amounting finally to only about 2°. Loose drift covers the bluffs and valleys very extensively, somewhat interfering with the recognition of continuations of strata. From the facts which we obtained with reference to the Laramie Group of this region we may regard it as composed entirely of sandstones, shales, marls, clays, and coals.

Near the base heavy sandstones set in, soon superseded, however, by shales. These contain strata of sandstones at varying intervals. A number of coal-beds were found overlying these sandstones. The coal is generally covered by a comparatively thin stratum of sandstone, upon which follow clays, shales, and arenaceous marls. Higher up we find a succession of sandstones interstratified with shale. Gypsum in the form of selenite is quite frequently found in the latter. The higher members of the group are composed of yellow and white sandstones, containing several beds of coal, and dark, often carbonaceous shales. Sandstones mediate the transition into the Lower Tertiary Groups. We may regard the lowest coal-horizon as the most productive one. In Colorado we find the same character exhibited as to the utility of the coal. The total thickness of this group, west of Rawlings Springs and from there northward, may be estimated at nearly 1,600 feet.

In the vicinity of Rawlings some coal is mined in the lower beds. The demand does not warrant the prosecution of work during the entire year, but a sufficiently large quantity can be disposed of to make the production of coal remunerative. Near Fillmore and Summit we found a number of abandoned openings on coal-banks, some of which appeared to extend into the veins for considerable distances. In most cases the roofs were either too unsafe, or the holes were full of water, so that we could not make any extended examinations. East of Fillmore we found an old tunnel, at the mouth of which a huge dump of slaked coal indicated that a good deal of work had been expended on the vein. A section obtained there of the strata immediately above the coal-bank may furnish a general idea of the beds usually associated with the coal. Beginning with the top of the small bluff into which the tunnel was driven we found:

k.	Yellow, middle-grained sandstones. Contain argillaceous bands	5 feet.
i.	Gray, laminated shales, exfoliating upon weathering	9 feet.
h.	Yellow sandstone, with reddish stains. Fossil plants	2 feet.
g.	White, coarse-grained, argillaceous sandstone, with thin seams of light-yellow shales	7 feet.
f.	Yellow sandstones, ferruginous and hard, with *Calamites* and other plants	3 feet.
e.	Light-gray very fine-grained shales with minute crystals of selenite	5 feet.
d.	White coarse-grained sandstone, readily weathering into rounded forms	6 feet.
c.	Gray and drab, highly argillaceous shales and clays, with leaves and selenite	4 feet.
b.	Carbonaceous shales, containing thin seams of coal	6 feet.
a.	Coal	8 feet.

In connection with these outcrops of coal we had occasion to observe the extensive alteration of exterior appearance produced by their taking fire. At a number of localities we had observed brilliant red shales with-

out being able properly to account for their presence. It was found that several of the dumps were ignited, a common condition due to spontaneous combustion of the coal, which is produced by the decomposition of pyrite. In the same manner probably the coal *in situ* took fire and burned so long as the supply of oxygen could sustain a flame. Through this process of metamorphosis by heat the overlying beds containing more or less hydrated ferric oxide were changed to a bright vermilion color. We found sandstones, the faces and edges of which had been literally glazed by the long-continued action of heat. Fragments were firmly baked together, and resembled cinders from a furnace. Purely argillaceous shales and clays had been thoroughly fritted, and were altered into very hard, compact porcelain jasper. When found in small pieces, this latter is generally red on the outside surface, but upon being broken it is of a greenish-blue color. This difference is due to coloring produced in the first instance by ferric and the second by ferrous oxides. Prof. J. A. Allen, of Cambridge, has observed similar occurrences, and has published a highly-interesting paper upon the subject.* Throughout the area covered by the Laramie Group, and in some of the Wasatch beds, we found the same red color of strata produced by the same causes.

In the vicinity of Salt Wells we observed the Laramie Group again exposed. It there follows a line of outcrop similar to that shown by the Fox Hills. Dipping in three directions, the exposure to the north occupies the smallest area. On the west side the beds dip off steeply from the Fox Hills, following a strike which carries them to Rock Springs. Here large masses of oysters were found along the slopes of small bluffs. They were determined as *Ostrea Wyomingensis* and *O. glabra*. Coal-beds are found here in the Laramie Group, a short distance above the Cretaceous strata. Their outcrops were too much decomposed to afford any material for analysis. I here insert an assay made by Professor Frazer, and published in the report for 1870. The coal is from Rock Springs, and there occurs as a direct continuation of the beds we observed northwest of Salt Wells:

	Per cent.
Volatile matter	42.62
Coke	54.88
Ash	11.00
Sulphur	00.50
	100.00

Following the Laramie beds along their strike, we are carried to the eastward and then southeast in a line reaching Point of Rocks. An analysis made by Professor Frazer of coal from this place yielded him:

	Per cent.
Moisture	8.54
Volatile matter	30.60
Carbon	52.34
Ash, white	8.52
	100.00

From a comparison of these results with those obtained by W. Ashburner, who analyzed some coal from Separation, it will be found that

* Metamorphism produced by the burning of lignite beds in Dakota and Montana. J. A. Allen, Boston, 1874.

some difference exists. The latter determined the composition as follows:

	Per cent.
Volatile matter	48.00
Fixed carbon	50.57
Ash	1.43
	100.00

Comparing these with the mean average taken from 34 analyses of Colorado coal, we find a striking constancy of the percentage of fixed carbon:

	Per cent.
Water	6.43
Fixed carbon	52.51
Volatile matter	34.09
Ash	6.83

It is a matter of experience that different banks of coal, though occurring in the same horizon, frequently vary considerably as to the quantity of ash they contain. It is due to more or less accidental admixtures, and frequently to inclusions of clay and gypsum between the narrow seams which traverse nearly all of the younger coals.

Besides these two "fields" we find no further outcrop of the Laramie Group in our district. An enormous amount of coal that may be utilized at some future time is stored within this area. At present, so abundant a supply is offered at the most advantageous localities that it may be centuries hence before the treasures of this section will be sought after.*

TERTIARY.

Wasatch Group.

Directly overlying the upper sandstones of the Laramie Group, we find an extensive series of sandstones, shales, and marls, which form the Wasatch Group. The most extensive section of the entire group may be obtained north of Salt Wells. Passing down along the northward sloping Laramie beds, we find a heavy mass of variegated marls overlying some shales and sands. Conformable with the underlying strata these dip northward at a diminishing angle. Deep cañons are cut into the marls, and some very grotesque forms are carved out of them by erosion. They present a very handsome variation of coloring. Red, brown, and maroon strata alternate with white, yellow, and greenish ones. Isolated strata of sandstone are found at several horizons. As a rule, the marls are highly arenaceous; but some strata can be found which are free from sand. At the base of these marls accumulations of conglomerate may be found at some places. The upper portions of the Wasatch Group are formed by yellow and brown shales and loosely-cemented sandstones. Some of the latter contain numerous siliceous concretions, which appear in the form of chalcedony and agate. In the upper sandstones and shales we find a number of Carbonaceous layers and some small seams of coal.

Passing over some rusty sandstones, we finally reach the base of the Green River series. At the point of greatest development which we observed, the lower marls reach a thickness of 600 to 700 feet. I regard

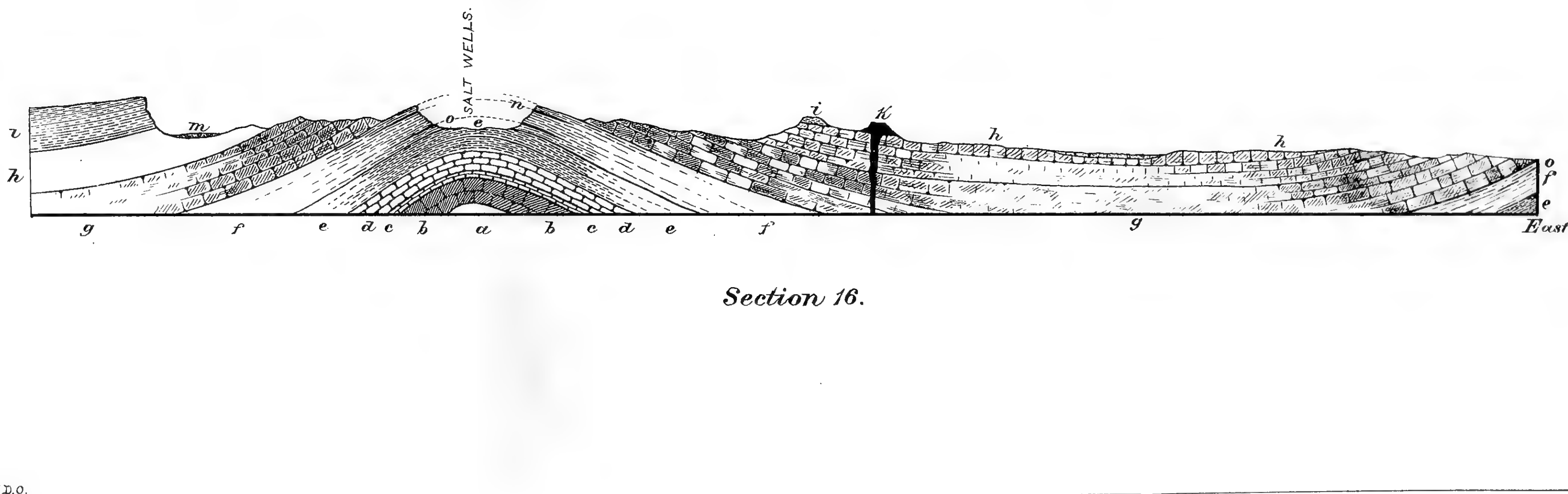
* NOTE.—In my report upon the coal-beds of Evanston, which is in preparation, I shall have occasion to enter into the interesting geological questions connected with the Laramie Group, as well as into the economic value of the various "lignitic" coals.—E.

them, from their position and character, as analogous to the Puerco marls of New Mexico and Colorado. The series of upper sandstones and shales reaches a thickness of about 600 feet. Within this region a number of volcanic eruptions have taken place. North and northeast of Salt Wells several buttes occur, forming prominent features in the landscape. Essex Mountain is one of these. From its summit we can trace, by the color, the extension of the Wasatch Group. At this locality the strata have assumed a horizontal position, farther north a very gentle southerly dip. Toward the west the area of the group is closed by the superposition of Green River beds. East and north the same strata spread widely. Following the trend of the outcropping volcanics we advance toward the railroad in a southeasterly line. After crossing a creek, which on some maps is designated as Sulphur Creek, we gradually rise to the highest elevations which the Wasatch attains in his region. Descending from a north to south ridge we see before us the wide expanse of Red Desert. A perfectly level valley of oval shape is surrounded on all sides by low bluffs. Toward the north the color of the soil is perfectly white, but farther south it turns to a brilliant red. Not a drop of water is found in that entire section of country. The red color of the desert-like depression is derived from the upper members of the Wasatch series. Northeast of Red Desert we find the extensive series of depressions which have been comprised under the name of Shoshone Basin. This appellation is given as a purely topographical one, without reference to the geognostic structure of the region. We find northward of Trail Lake a number of others within the area of the same group. In this vicinity the strata are very regular in their arrangement. A very slight dip toward the basin, together with a general inclination southward, may be observed, however. Northwest of Trail Lake, near the base of Station 21, the marls are again exposed. From a long distance, even, may they be recognized by their characteristic coloring. Typical *mauvaises terres* are carved out of the marls at this locality.

Northeast of Trail Lake the strata continue in regular succession, showing a bright red color near the upper portions of the bluffs. This is due to the burning of coal beds. By this process the shales thus changed have been rendered less liable to disintegration, so that the red color is essentially confined to a narrow, almost horizontal band. A number of small lakes and several dry lake-beds were found here, still belonging to the depression of the Shoshone Basin. Near one of these a large number of mud springs were found, which shall be referred to again below. So far as we could determine, the thickness of the upper portion of the Wasatch diminishes considerably as we approach the Sweetwater. Examining the most northerly outcrops of the group we find that it ends in a succession of small bluffs as we reach the metamorphic and Prozoic area. A little farther east, along the southern slope of the Sweetwater Hills, the junction is obscured by drift and accumulations of sand.

This latter feature is one which was very extensively noticed throughout the Wasatch region. A broad belt of sand dunes stretches diagonally across the southern portion of our district, ending at Sandy Creek Pass. Traveling toward the eastern edge of the Wasatch exposure, we find everything rendered indistinct by masses of loose drift scattered over the valleys and bluffs. West of Creston station we obtain a comparatively good view of the lower portions of the group. Here the sandstones are decidedly amplified as compared to those farther north, and the arenaceous shales and marls are well developed. Large masses of crystallized selenite are scattered over the bluffs and hill-sides, com-

Plate VI.



Section 16.

posed of the latter, producing a very brilliant effect of reflection in the sunlight. East of Creston we are once more fairly in the Laramie Group. Isolated beds of the former occupy some of the higher points east of the border of the Wasatch; but the upper members of the Laramie and the lower ones of the Wasatch are so very much alike that it is almost an impossibility to separate them. Within the region where we had occasion to observe these two groups in contact, I noticed no evidence of any unconformability. Indeed, it was often only by the aid of the higher, colored beds that I was enabled to draw the dividing line.

So far as could be determined, the Wasatch beds reach northward very nearly to the granites between Sweetwater and Whiskey Gaps. From there westward their limits are determined first by the Sweetwater Group and then by the Green River series. On the east side the termination of the Wasatch is characterized by the appearance of the Laramie.

Section XVI* illustrates the relative positions of the groups above discussed. The older strata, which make their appearance farther south, are represented as taking part in the anticlinal upheaval (*D*), which terminates directly north of Salt Wells. Colorado shales (*e*) are the oldest beds exposed on the surface. Dipping off in either direction we find the Fox Hills series (*f*). This is overlaid by Laramie (*g*). Both the upper (*n*) and the lower (*o*) horizons in which coal is found have been marked.

Covering the Laramie, after a short area of out-crop to the west, a longer one to the east, we find the Wasatch Group (*h*). Eastward this forms a shallow synclinal basin. This, taken in connection with the general dip to the southward, produces the Shoshone Basin. Green River beds (*i*) overlie the Wasatch to the westward, but farther east are found only in scattered remnants along this line. Basaltic eruptions (*k*) have been represented. They occur quite frequently in the Wasatch. Two extensive drift-areas (*l* and *m*) are found in the Shoshone Basin and on Packer's Creek, the latter being west of the anticlinal.

Some very interesting information may be obtained regarding the distribution of these groups from the section of artesian wells bored along the Union Pacific Railroad.† The greatest depth reached by boring along this portion of the road is at Rock Springs, 1,154 feet. This penetrates the entire Laramie Group and reaches down far into the Fox Hill series. From the data here obtained, the position of the Wasatch appears to be constant, and the distribution of coal, in two horizons, to remain equally so.

Mud springs.

It has been mentioned above that near one of the lakes in the Shoshone Basin a large number of mud springs were found. They have been partially described in the itinerary. On the eastern shore of Death Lake we observed mounds shaped like bee-hives, which generally contained a circular opening near the top filled with muddy water. They are located about 50 feet above the lake surface, but extend downward to the water's edge. Within the region there is no flowing surface-water. We found that the mounds varied from a few inches in height to about 15 feet. None were found containing water higher than 4 feet. They are circular or oval upon cross-section, and the opening containing the water adapts itself to the shape of the mound. A mound of 4 feet in

---

* I may here state that none of the sections are prepared on scale, owing to the want of a reliable map.—E.

† Bulletin U. S. Geol. Surv., vol. iii., No. 1, Dr. Hayden "On Artesian Borings," &c., p. 181.

hight will be about 6 feet in diameter at the base and 2 feet at the top. The water comes up to the top within about a quarter or an eighth of an inch. It is cold and muddy, containing exceedingly fine silt and gelatinous mud in suspension. Upon watching the surface of the water an occasional rise of a bubble can be seen, which disturbs it. Then a small amount may flow over onto the upper rim of the cone containing it. The moisture here deposited soon evaporates, but the mud and silt remain. In this manner the mounds are formed. If they attain a height of more than 4 or 5 feet, the upper opening begins to close, and finally nothing remains but an accumulation of mud.

This mud is entirely destitute of vegetation, and exceedingly loose when dry. An animal will sink in deeply while passing over it. Springs were seen, containing a water-opening of only a few inches in diameter, but one was found which measured fully 30 yards. Varying from the others, the water was here not exposed upon the surface, but a film of fine mud had formed over it. It was found that the consistency of the mud mixture was sufficiently great to sustain a crust of several inches in thickness. Any object weighing enough to break through the covering could be thrown upon it and would immediately sink out of sight. We were not prepared to take soundings, but established the fact that many of the cylindrical tubes containing the mud-water were more than 10 feet in vertical depth. At least for that distance an old lodge-pole which we happened to find could readily be introduced. Breaking open a small mound, which showed an aperture of about 3 inches in diameter, it was seen that the cylinder is lined with a coating of very fine blue mud, about half an inch in thickness. The question soon arose, was the water held in its position by hydrostatic pressure, or was an accumulation of some kind of gas the cause of its rise in the tubes. A rifle-ball shot down vertically into one of the openings produced a sudden eruption of the whole mass. Water and mud were thrown to a height of about 10 feet, covering the luckless experimenter from head to foot. From a safer distance the trial was several times repeated and almost always followed by the same result. After everything quieted, the water was found to stand from 2 inches to 8 inches lower in the tube than before. Crude as this test may be, it shows the presence of gas at some depth, held there under mechanical pressure. Probably some chemical decomposition furnishes the gas, which has given rise to the formation and perpetuation of these springs. We estimated their number at about 400, covering an area of about half a square mile. Innumerable bones of animals, who here sought to quench their thirst, prove the treacherous character of the soil. Frequently the surface, which appears perfectly dry and solid, may be shaken by the foot for more than 20 feet. The entire place is undermined and filled with muddy water, so that it requires some care to get over it without mishap. None of the mud springs that have heretofore been discovered seem to possess exactly the same character as these, nor are they so extensive.

Green River Group.

As indicated in Section XVI, the Green River beds follow directly upon the Wasatch series. Packer's Creek flows in a southerly direction into Bitter Creek, a short distance east of Rock Springs. West of it we observe a high ridge composed of the light Green River shales. A gentle dip to the westward is soon obliterated and the strata continues very nearly horizontally. This slight inclination continues for a long distance westward. Early erosion has removed large masses of the strata be-

longing to this group, and we therefore find the Wasatch exposed for a number of miles upstream. Eastward the Green River makes a sharp turn and passes north of Essex Mountain. It there shows a very small southwesterly dip; continuing northward we find the group thining out very decidedly. It extends up to Station 21, overlying Wasatch. This point may essentially be regarded as its northeastern termination. From there the northern line of outcrop runs in a direction south of west, and the eastern one about southeast. Remnants of Green River beds are left on the Wasatch at several places, showing that the group at one time covered a much more extensive area.

In this section of our district the lower members of the group are composed of gray and bluish shales, more or less calcareous and arenaceous. Higher up we find yellow and light brown shales, mostly very sandy, but containing strata of impure, argillaceous limestones. Above these follow concretionary sandstones and shales, of yellow and rusty brown color. The former contain one very prominent horizon of siliceous material, appearing in the form of chalcedony and agate. Near the base a thin stratum of cölite was found. It shows the single grains of concentric structure firmly cemented by quartz. Another similar bed was observed higher up in the shales, where the oölite was associated with large quantities of silicified wood. Emmons has found* a similar occurrence of oölite near the base of the Green River series at a locality south of Red Desert Station. It varies somewhat in character from that which we observed, being of a gray color and containing calcium carbonate. The specimens we found are red, brown, and yellow, and silicified throughout. It was observed about 28 miles west of north of Red Desert Station. The higher horizon was noticed on Station 21. It does not appear that the band extends for any considerable horizontal distance. Near the base of the series we find the characteristic deposits which have been designated as "paper shales." It is probably not intended that this term should be synonymous with the German "*Papp-deckel-Schiefer*" (pasteboard slates), but in point of fact the latter variety does here occur. They are composed of extremely thin, tough laminæ, which exfoliate upon exposure. In this condition they closely resemble pasteboard which has been soaked in water. Both when compact and decomposed, they are more or less flexible. Mainly calcium carbonate, aluminium silicate, and minute grains of clear quartz compose them. Frequently they are bituminous, sometimes sufficiently so to burn. Associated with these peculiar shales we found numerous banks of "cone-in-cone" (*Nagel-Kalk* of Germans). Their horizon is about 350 feet above the base of the group. Together with them, and a little higher up, remains of fishes were observed. Unfortunately the shales were there (north of Mount Essex) so thoroughly decomposed and disintegrated that no good specimens could be obtained.

It has been mentioned in previous pages that the Green River Group shows a general thinning out toward the north. Not only do the lower shales decrease in vertical dimensions, but the upper sandstones become very much thinner. West of Packer's Creek we find the total thickness of the Green River series to be 1,700 to 1,800 feet. Of these the upper sandstones with their shales occupy about 800 to 900 feet, and the arenaceous beds near the base about 150 to 200. This leaves an average thickness of 700 to 800 feet for the shales. Approaching the northern termination of the group its total thickness amounts only to about 1,200 feet; 100 to 150 feet of lower sandstones and arenaceous shales, 650 to 700

---

*Geol. Expl. Fortieth Par., vol. ii, 1877, p. 212.

feet of shales, and 350 to 400 feet for the upper sandstone series. At many places this latter has been totally removed by erosion, leaving nothing but the shales to occupy the highest points.

Throughout the region the beds of the Green River series show a characteristic style of weathering. Wherever the progress of erosion, either fluviatile or atmospheric, is very slow, there the outlines presented by members of this group are gently rounded. If the erosive agents are more active, steep, picturesque forms result. Tables and buttes, resembling those near Green River City in general structure, are found in the western portion of our district. From the lithological character of the strata we may infer that the lower series was deposited into deep, still water, while the upper essentially represents shore deposits. Very few fossils were obtained, and these only fragmentary, for the reason that the shales were too much decomposed and we could not spare any time for the purpose of excavating. It seems, too, that the localities farther west and southwest contained a much more extensive fauna than the eastern ones. In Northern Colorado and other regions to the eastward, the Green River Group is almost entirely destitute of palæontological remains.

Bridger Group.

In 1870 Dr. Hayden found a number of outcrops of the Bridger Group on the drainage of the Sandies. From his description it appears that they were superimposed upon the Green River series. Within our district a number of exposures were observed that have been referred to the Bridger. Forming the summit of Station 21 we found a series of light-colored clays and shales, partly calcareous. In these a few leaves occurred, numerous specimens of *Lymnæa*, and remains of turtles. The color of the beds containing them is either white, yellow, or very light pink. Toward the west the summits of Steamboat Buttes are composed of the same material. It was found that wherever the bluffs rose several hundred feet above the general upper level of the western portion of our district, the highest portions were found to be composed of Bridger strata. An enormous amount of erosion has taken place in this region, and has broken all continuity between the outcrops. Enough was seen, however, to let it appear certain that the entire area was here at one time covered with a sheet of Bridger beds extending nearly to the base of the Wind River Mountains and reaching northeastward beyond Station 21. Both to the north and east the beds appear to thin out. The more northerly outcrops of both the Green River and Bridger Groups participate in the prevailing slight southerly dip, amounting from 1° to 4°. Remains of turtles, probably *Trionyx*, were found at a number of localities where the Bridger was exposed, and below them Mr. Howes obtained a specimen apparently belonging to *Crocodilus*. Owing to the erosion of the entire region we find only the lower portions of the Bridger series. As a maximum thickness which this attains in our district we may regard 500 feet. Toward the south and southwest it grows much thicker, after passing beyond the limits of the area we surveyed.

Pliocene Group.

Within the narrow depression between the subsidiary Prozoic Range and the western base of the Wind River Mountains, we find a local deposit which is probably of Pliocene age. The valley is of narrow elliptic shape, trending about northwest to southeast. It is filled with a loose white and yellow deposit of clays and marls. Some arenaceous beds

occur near the base. Stratification is not very apparent in it. At some points, where the granites of the lower range form gaps, the white, chalk-like bluffs extend southward for a short distance. So far as could be determined, they are unconformable with the Green River series, which they join along the Little Sandy Creek. At some points the imperfectly defined strata of this Pliocene series show a dip of 2° and 3° to the northeast. About 5 miles east of the Little Sandy it ends, very near South Pass. It seems as if portions of it had formerly extended farther east and south, but had been removed by erosion. No fossils were found, but some specimens of a small *Pupa*. At no place do we find a favorable section of the group, and an estimate of its thickness is therefore necessarily not very reliable. I regard it as about 300 feet.

Wyoming conglomerate.

Wherever we find Tertiary strata which have been but little disturbed by subsequent erosion, we observe extensive deposits of this loose, irregular conglomerate. Along the southern slope of the Sweetwater Mountains it is very abundant, totally obscuring the junction lines of the different groups. On the summit of Station 21 it is found as a small remnant, about 12 feet in thickness, forming the very highest point. Indians had here built up a small "lookout" with the bowlders. Now this is disturbed, as our monument occupies its place. Upon the summits of some of the higher Tertiary hills this conglomerate affords the only material for such purposes, as the strata weather into small fragments, leaving no bowlders of sufficient size. Table Hills and Steamboat Buttes, a little farther west, are covered with the same material. At these places some of the metamorphic bowlders are so large that they may have been and probably were transported by ice. Within the Pliocene valley west of South Pass the same conglomerate occurs in abundance. It is scattered to a greater or less extent all over the country which has been subjected to extensive erosion. Having been removed from the regions where it was first deposited, it was dropped in the direction taken by the waters which so greatly modified the surface of the country. Although our observations are somewhat imperfect on account of the erosion following the regular deposition of Tertiary groups, I am inclined to regard the maximum accumulation of this conglomerate as occurring along the shores of the former Tertiary lakes.

ERUPTIVES.

Mention has been made of the eruptives which form a series of hills and bluffs north and northeast of Salt Wells. Mount Essex is the principal one of these. A high bluff is formed by volcanic material which has been ejected through the strata of the Wasatch Group. Sloping gently to the northward, we find th it the summit is essentially a small plateau, containing one prominent, conical point. To the south and east the mountain presents vertical, rocky faces, which surmount a steep, furrowed slope. The rock is dark gray to black, more or less vesicular, and contains small crystals of augite and biotite. Immediately south of Essex Mountain is a table-topped hill, which on some maps is marked as "Black Butte." Here the lava has escaped through a fissure trending about north 45° west, and has covered the Wasatch beds with about 400 feet of black rock. It is somewhat columnar, and presents a nearly vertical face on all sides. West of Essex Mountain, on the drainage of Packer's Creek, is an isolated needle of basalt, known as Rock Point.

It is about 250 feet high, has a very narrow base, and forms a prominent feature in the landscape. Southeast of the mountain we observe a number of similar buttes, which approximately follow a course of east 45° south. Most of them are table-topped hills, from 600 to 900 feet in height, showing volcanic caps of varying thicknesses. They may be estimated at 200 to 700 feet.

More interesting than the table-topped hills was one occurrence at Basalt Springs. There a ridge, trending south of east and composed of Wasatch beds, was covered with an extensive flow of basaltoid rock. On the summit of the ridge, three cone-shaped hills were noticed standing in its strike. One of these presented the aspect of a crater, while the other two resembled the highest point of Mount Essex. Along the northern slope of the ridge the volcanics were broken off abruptly, and tumbled down the side in most chaotic masses. Huge bowlders, weighing hundreds of tons, were piled on top of each other, and composed the slope directly below the vertical face of the rock *in situ*. It was found that a process of undermining has caused a removal of Wasatch beds, and that the overlying lava had fallen down into the excavation thus produced. Near the unbroken northern edge of the ridge the last fissure formed by this separation was observed. It extended in a nearly straight line for several hundred yards, was over 40 yards deep, and not more than 20 feet wide at the top, practically closed below. The movement of this huge mass was evidently arrested by the accumulated bowlders on the slope a little lower down.

These buttes and hills furnish an indication of the extent of erosion which took place in this region. Through fissures having a strike parallel among themselves, the lava was ejected and poured over the level of the Wasatch, and, in part, Laramie strata. Probably the several areas of eruption were disconnected from the beginning. Fluviatile erosion, shaping its course in accordance with the horizontal distribution of this hard rock, cut deep valleys along such places where it could successfully attack the beds. By undermining the volcanics a diminution of their area was achieved and they were forced to assume the peculiar forms that at present characterize them. Tendency to columnar structure, or the pronounced development thereof, greatly aided the formation of vertical faces in the lavas. After the masses had fallen, their removal and transportation were effected by the same agents that excavated the valleys. In the case of the Basalt Springs ridge they were individually too huge to be attacked, therefore retain their original position.

Upon critical examination we find that the volcanics of these hills show highly interesting features. Some of them are gray and grayish-brown, showing a microcrystalline groundmass, with no visible segregated mineral but biotite; others are decidedly basaltic and contain olivine. During the progress of the Fortieth Parallel Survey this region was visited and the rocks subjected to microscopical examination. The first-mentioned variety proves to be a leucitophyrite.* It appears that the groundmass is composed entirely of minute crystals of leucite. This occurrence is one of great interest, inasmuch as it forms the first one of this character on the North American continent. In Europe, the leucite rocks have attained great celebrity on account of their unique character as well as on account of the beautiful crystals they contain.

By the discoverers of the peculiar mineralogical constitution of these eruptives, the entire series of hills has been named "Leucite Hills." At Mount Essex I observed the most typical leucitophyrite. It seems to be

* U. S. Geol. Surv. Fortieth Par., vol. vi, p. 260.

very intimately associated with the basalts of the immediate surroundings. An analysis of a specimen from this locality is appended, which shows a remarkable similarity of composition with some of the European leucites.*

Silica	54.42
Alumina	13.37
Ferric oxide	0.61
Ferrous oxide	3.52
Lime	4.38
Magnesia	6.37
Soda	1.60
Potassa	10.73
Lithia	trace.
Carbonic acid	1.82
Water	2.76
	99.58

POST-TERTIARY EROSION.

The extent and distribution of post-Tertiary erosion indicates, in a measure, the condition of the surface after the close of Tertiary sedimentation. We find that south of the Wind River Mountains, enormous masses of beds have been removed in a southwesterly direction. This is in conformity with the general dip of the strata, as here exhibited. Deep, wide valleys have been cut into the readily yielding material, and, indeed, the majority of the higher beds have been entirely removed. South of the Sweetwater Hills the drainage has carried away less material than farther west, owing, no doubt, to the comparatively short course of the ancient streams. While those flowing toward the Sweetwater found an opening to permit their passage for an unlimited distance, the southward drainage was arrested by the existence of a shallow basin. Pouring into this the water was retained in a series of lakes. From the western as well as eastern rim of this depression the streams flowed into the Pacific and Atlantic Oceans respectively. They cut away large portions of the strata leaving isolated remnants of younger groups superimposed upon the older ones. Within the Shoshone Basin the formerly existing streams have formed narrow valleys, bordered by steep bluffs, and showing exceedingly gentle slopes. No doubt, a considerable number of square miles were there at one time covered by bodies of standing water. The "flats" we find to-day are ample evidence thereof. East of the basin the drainage was essentially a north to south one, following the strike of the strata and receiving tributaries from the east along the slope of the anticlinal uplift. Although a very large quantity of material has here been carried away, the process of denudation was not so extensive as farther west. To the eastward of the anticlinal ridge mainly two great valleys, trending north and south, were produced by early erosion. One of them, certainly, and probably both contained lakes of large dimensions.

We observe from this that the younger Tertiary Groups probably occupied a much greater area to the east than they do now. Westward the younger beds showed a more decided development and rose to higher absolute elevation.

GLACIATION.

In the vicinity of Table Hills and Steamboat Buttes we find deposits of erratic material that appears to have been transported by ice. Huge blocks of granite and schists occupy the summits and higher ridges, distributed in an irregular arrangement. Some of them have rolled

* U. S. Geol. Surv. Fortieth Par., vol. ii, p. 237.

down into the lower country and appear as lost strangers amid the recent Tertiary deposits. They extend for some distance eastward. Dr. Hayden says of them: "The immense quantities of granite bowlders, red and gray, * * * must have been swept down from the Wind River Mountains. Some of these granite masses are 10 to 15 feet in diameter; others are sunk so deep in the earth that they appear to be in place." If they be regarded as glacial, I should consider them due to the effects of the extensive ice-field which left its ground moraines near Camp Stambaugh. It passed downward from the southern end of the range, and may have extended across the gulfs which now separate the erratic bowlders and the well-defined moraines. As the former appear only sporadically, not following any definite horizontal arrangement, I do not class them among moraines, but consider them as "scattered glacial drift." Probably they were carried southward to a region where the glaciers had lost the greater portion of their terminal moraines, and found no material for the formation of others. Thus, then, do these rocks indicate the extreme sourthern limits which were reached by the moving ice-fields of the Wind River Range.

LAKE DEPOSITS.

From the structure of this southern area, and from the features exhibited by post-Tertiary erosion, we may expect to find a large quantity of lake-beds. In the Shoshone Basin the majority of them are located. We observe there a number of lakes which contain water throughout the entire year, although receiving supplies during only a few months. In almost every instance it was seen that, within comparatively recent times, their horizontal extent was much greater than it is now. Slight rises, separating perhaps a dry bed from a lake, were then overflowed, and large bodies of water appeared on the surface where now we find only smaller ones or none at all. On the surface the lake deposits appear perfectly level or slightly concave accumulations of fine arenaceous mud containing strata of sand. In case any strata showing bright colors were cut by the drainage which fed the former lakes, we find the fact indicated by layers of clay and sand exhibiting red, brown, white, and yellow bands. White efflorescences of alkali cover those deposits which contain water during a portion of the year. Sodium sulphate and sodium chloride compose the main bulk of this "alkali." Generally the lake deposits occupy depressions of oval form and jut directly against the surrounding strata. Water entered these old lakes from several directions usually, the prevailing one usually being indicated by the longer dimensions of the deposits.

In case no water has stood in the depressions for a long term of years, the efflorescences will have disappeared entirely, and nothing remains but the sterile waste exposing fine mud intermixed with some sand. An instance of this kind is presented by Red Desert. For centuries, perhaps, no water has been standing on the old lake bottom. It is hard and firm, baked by the hot sun of many successive summers. Southeast of Mount Essex we noticed a number of such beds. South of the Seminole Hills two extensive valleys show deposits of the same nature. One of them, lying between the exposure of Colorado shales and the bluff formed by the Fox Hills series, is of considerable extent. The other one, to the westward, is smaller.

Dependent, to a certain extent, upon the area of the deposits, is their thickness. From temporary creeks which have cut narrow gullies into the soft material, we find that it exceeds 20 to 30 feet in many places.

On the map which will appear subsequent to this report the lake deposits are indicated, and it will be seen that the southern area of our district was formerly much better supplied with water than it is to-day. So far as could be determined from the general level and from the lithological character of the lake-beds, they were synchronously filled with water. The persistence of some of them as lakes to the present time appears to be due entirely to the composition of the deposits underlying. Dry beds were in close proximity to lakes of considerable size, and more than once were they observed to show a lower level than the latter. In such a case not unfrequently a more or less complete saturation of the subsoil could be noticed, which indicates that, first, it is in hydrological connection with that of the lake close by, and, secondly, that the dry bed is probably flooded during the wet season. The latter fact is pointed out, also, by the existence of alkaline deposits upon the surface.

DRIFT.

An abundant supply of drift covers the southern portion of our district. Wherever it is composed of metamorphic and old sedimentary material, we may regard it as redeposited Wyoming conglomerate. The sandstones and shales prevailing in this region disintegrate readily and form a species of finely comminuted drift which is spread over all the bluffs and valleys. Coarse drift, in large masses, is necessarily of rare occurrence. It is found, however, in the vicinity of all the older formations.

From the character of the strata which supply the material for the production of drift it is evident that a large quantity of it must partake of the character of soil. The composition of this soil is a good one for agricultural purposes, as will readily be seen if we consider the nature of the beds furnishing it. Want of water, however, precludes the possibility of ever regarding this region as an agricultural one. Another portion of the drift is found in the form of sand, which forms extensive moving deposits.

SAND DUNES.

In previous pages allusion has been made to the "sand belt" stretching diagonally across the southern portion of our district. It may be stated as being 70 miles in length and from 5 to 10 miles in width. Beginning in the west, near Packer's Creek, it follows a line north of east, which brings it to the southern base of Mount Essex; widening from there on, it reaches Trail Lake; passing on the south side of the lake it extends to Death Lake; thence it passes over the anticlinal upheaval, disappearing near the summit, and continues from there to Sandy Creek Pass, at the eastern termination of the Seminole Hills. On the eastern side of Sweetwater and Whiskey Gaps we find similar dunes, although they are not so extensive.

Composing these dunes we observe a fine white and light yellow sand. It is almost pure quartz, containing but slight admixtures of feldspar. From the disintegrating sandstones and arenaceous marls, which are so prevalent in this southern area, atmospheric precipitation causes a removal of the more easily transported particles. These are the cementing clays. In this manner the sand is left entirely free, scattered over the hills and bluffs and along the numerous slopes. Westerly winds exist in this region during the greater portion of the year, and are mostly very violent. By them the sand is picked up and carried along in a line indicating the greatest force of the wind. Wherever a gap occurs in a ridge

which breaks the force of the wind, there we find the greatest accumulations of sand. It is carried thither, but the wind is forced to take an upward course, and much of the sand must fall. Near the Sweetwater and Whiskey Gaps, and at Sandy Creek Pass, the fine sand is blown up upon the hillsides for a distance of 500 to 600 feet. It is always found most abundantly on those hills which present a face to the southwest. The southern slopes are covered with a thin layer, but upon them we rarely find an accumulation of dunes. On account of the persistency of the wind the upper portions of this sand are very loosely deposited, and are constantly shifting. An animal in passing over it will sink in to the knees. No vegetation can take hold on the dunes. At a few places depressions were found in which the sand had somewhat hardened, and sagebrush took advantage of these occurrences.

From a distance the dunes resemble the waves of a "chopped" sea. Sloping gently toward the west, each wave shows a steep incline on the opposite side. "Ripple-marks," not distinguishable in their form from those produced by water, cover the western slope. In very windy weather a long-continued yellow cloud of dust may be seen along this "sand-belt." It rises high into the air and deposits its sand in a line parallel with the direction of the wind. With but little motion of the atmosphere the movement of the dunes could be favorably studied. Rolling upward along the western slope of an individual dune, the particles of sand steadily advance in parallel, successive rows. Reaching the cap of the wave, each row rolls down the eastern incline, there again to be picked up and marched farther eastward.

An interesting occurrence to us was the fact that many of the lakes which were located in the immediate vicinity of this series of dunes contained water, while those removed some distance from it were dry. I explain this by assuming that the precipitated moisture, the quantity of which is small at best, can more readily soak into the sand and be retained for a long time, preserved from evaporation. In this way small springs or underground water-courses can be formed, which will furnish the lakes near by with a greater absolute quantity of water than those receive which are dependent upon surface-drainage and direct precipitation. Whether such springs remain even only partially active during the entire summer is very doubtful. The quantity of water which is carried into the lakes during the wet season is so much in excess, however, over that which others receive having the same drainage area that it is not reduced to the same extent by evaporation. Another factor here enters into consideration, the capacity for saturation. While the moisture which appears during the summer in the form of slight precipitations, such as dew and brief showers, is mostly lost very rapidly by evaporation, the peculiar physical conditions of the sand permit it to penetrate to some depth. In this manner the supply of the lake is not drawn upon by exhausted surrounding beds of the same level, and will be diminished more slowly in consequence.

As a necessary consequence of the vicinity of these lakes to the sand area, we find considerable masses of quicksand along some of their shores: Near Sandy Creek Pass a considerable number of lakes, of varying sizes, occur directly in the sand dunes. On account of the saturated condition in which the sands have here remained for a long period of time, they could not be transported by the wind wherever the grains were thus bound together by moisture. In consequence some soil was formed there. Grassy vegetation soon took advantage of this, and we now find some very fine meadows bordering the lakes. Rising only a short distance above their level, however, we are in loose sand once more.

A determination of the thickness of these sand dunes is somewhat difficult. We may say that about 80 feet would prove to be an average. Some of them were found to be several hundred feet high, while others were not over 20 feet. The largest accumulations occur on the northern side of the "belt" and at such points where some immovable obstacle is presented to the general course followed by the wind.

RÉSUMÉ OF THE DEPRESSED SOUTHERN AREA.

Among the formations found in this area, the most interesting one is that composed of the Tertiary groups. In preceding pages I have simply furnished a description of their geognostic features, omitting to make any allusion to their position in a classificatory system. Many different views are held upon this subject, emanating principally from the fact that the various classifications have been advanced by stratigraphists and palæontologists following various special lines of inquiry. It is impossible, at the present time, to reconcile the different opinions, and all that can be done is to weigh the evidence for and against each one, eliminating those that are untenable, and thus arrive at satisfactory conclusions. The material now on hand ought to be sufficiently instructive to enable some one to accomplish this desirable end. Until this work is accomplished, each geologist who has made any examination of the younger formations of the West, will, essentially, have his own private classification. In the subjoined pages I shall present the groups in such order as I have found them in the field, and shall assign to them positions in classification to which I believe them entitled.

Six groups of Tertiary deposits are found in our district—Wasatch, Green River, Bridger, Sweetwater, Niobrara, and Wyoming conglomerate. Of these the Wasatch and Green River Groups are certainly conformable. With regard to the Green River and Bridger I cannot speak with certainty, as the latter is too imperfectly represented in our district. Direct connection was observed between the Wasatch and Sweetwater, and again between the Sweetwater and Niobrara. Both of these junctions proved to be unconformable. We may regard, therefore, the Sweetwater Group as of local character rather than belonging to a regular and typical succession of Tertiary groups.

If we study these groups in connection with their vertebrate remains only, and compare them with occurrences of other countries, they will all be considered older than if their fossil flora is taken as the standard of measurement and identity. Regarding the Cretaceous formation as closed by the Fox Hills, and the Laramie Group as forming an independent transitional formation, we must necessarily begin the Tertiary with the Wasatch Group. This, then, forms either a part or the whole of the equivalent of *Eocene* of other countries. Within our district and elsewhere the Green River immediately follows upon the Wasatch. In its evolutional history, and in the class of its component strata, the Green River Group marks the advent of a new era. Fauna and flora, as compared to those of the Wasatch, are changed; with them the beds in which they are contained. Unconformities between the two are not wanting, although none exist in our district. As the Wasatch essentially represents an epoch of definite type, totally differing from that of the Green River period, I do not feel inclined to regard the two as belonging to the same division of the Tertiary formation, but place the Green River series at the base of the *Miocene*.

As a rule, the Bridger is directly superimposed upon the Green River. Its relative position is fully established, therefore, and it enters the reg-

ular succession without difficulty. A more intricate question is presented in the position occupied by the Sweetwater Group. By Dr. Hayden it is considered as being of the same age as the Wind River Group. This latter he places under the White River series, which is, according to him, probably synchronous with the Bridger. He places, therefore, the Sweetwater Group between Green River and Bridger. Comstock finds its resemblance greater to Bridger than to Green River, and King places the White River above the Bridger. But little applicable information could be obtained from the stratigraphical relations of these groups within our district. Reviewing their evidence so far as it pertains to this point, we find a few facts which may tend to throw some light upon the subject. Station 21 is located upon Bridger, overlying Green River. Had the hills composed of Sweetwater beds existed at the time the Bridger was deposited, we would expect to find, from the configuration of the country, Bridger superimposed upon Sweetwater, or evidence of its having been removed. Neither was observed. The Sweetwater Hills most closely approaching the Bridger show no evidence of having been extensively denuded at that locality. The system of drainage by which the Bridger beds of that immediate region were cut, is the one which must have existed prior to the deposition of the Sweetwater Group. For these reasons I place the latter as chronologically succeeding the Bridger. Younger Tertiary beds, which are found in the Sweetwater Valley, Dr. Hayden has shown to be identical with the Pliocene deposits of the Niobrara River. To the same group I count the local Pliocene strata west of South Pass. As the youngest Tertiary Group, we have the Wyoming conglomerates. Although this enumeration of groups comprises but a portion of those forming the entire Tertiary formation of the West, we may regard their relative position as established. Difference of opinion prevails, however, as to the places they should occupy in systematic classification.

The following table will furnish a synopsis of the formations younger than Cretaceous observed in the Sweetwater district:

Formation.	Division.	Group.
Quaternary	Upper	Sand-dunes, soil, loose drift, and gravel.
	Lower	Lake beds, glacial deposits, and old river-drift.
Tertiary	Pliocene	Wyoming conglomerates.
		Niobrara Group.
	Miocene	Sweetwater Group.
		Bridger Group.
		Green River Group.
	Eocene	Wasatch Group.
Post-cretaceous	Laramie	Laramie Group.
Cretaceous	Upper	Fox Hills Group.

Besides the Tertiary groups, the sand-dunes of this area furnished a subject of great interest. We had an excellent opportunity of studying them and obtained some instructive data. Their behavior with reference to bodies of standing water is singular, and yet natural when understood. More striking than the occurrence of the dunes is that of the mud-springs. But few localities are known where they exist, and never, to my knowledge, have they been found to exhibit the same type as within our district.

CHAPTER V.

ECONOMIC GEOLOGY OF THE SWEETWATER DISTRICT.

GOLD.

In Chapter I the auriferous schists of the Sweetwater region have been spoken of. It will be remembered that they were regarded as the oldest metamorphic series of the region. In 1867 the first ore-bearing lodes were discovered in the vicinity of South Pass and north of Camp Stambaugh. The former was called the Shoshone, the latter the Miner's Delight district. For a number of years lode-mining and gulch-mining were carried on with varying success. Partly the discovery of other regions promising greater remuneration, partly the speculative tendency which had taken possession of the Sweetwater mining operations, caused an abandonment of the greater portion of the mines. During the time that I visited the districts (July and August), but very little work was carried on and few of the mines only could be examined. At Miner's Delight a new impulse seemed to have been given to mining operations, and some work was just being taken in hand at the time. Information as to the former condition and production of these mines may be obtained from the reports of R. W. Raymond, United States Mining Commissioner.

AURIFEROUS VEINS.

South Pass City.—This town is located in a narrow gulch on Willow Creek. During the first flush of mining excitement it attained quite a considerable size, but since that time many of the stores and dwellings have been abandoned. The veins were discovered on the surrounding hills and determined the site of the settlement.

Cariso Mine.

The Cariso vein was discovered in 1867. It is situated on a hill directly northeast of the town, on the south side of the stage-road. Three main shafts have been sunk on the vein, the Cariso, Marshal or East End, and West End shafts. In the West End some stoping has been done. A drift connects the Marshal with a smaller shaft still farther east. The main shaft has been sunk to a depth of a little over 200 feet, the Marshal to about 90 feet, and the West End to 60 feet. Buildings above ground are still in good condition, as is the machinery. Within the mine some timbering has been done to prevent "scales" from coming down. At the time of my visit the mine was lying idle. It is owned at present by Mr. B. Roberts and superintended by Mr. H. Ridell. I understood that work was to be resumed shortly, upon the arrival of some new machinery.

Having a strike of about north 43° east, the vein is inclosed between beds of gneissoid schists. A dip of about 75 degrees (from the horizontal) is noticeable in the vein. Both strike and dip conform entirely with

those of the schists. At that locality the latter show the usual variations with certain zones; *e. g.*, substitution of hornblende or chlorite for mica. The width of the vein varies from 2 to 5 feet, as a rule growing wider with increasing depth. Granular quartz composes the gangue-rock. Near the surface this quartz is stained red and brown from the decomposition of pyrite. In certain portions of the mine it is very much shattered and may be easily worked out. Gold occurs free within the "surface-ores" to a depth of about 80 feet. It is primarily contained in the pyrite, but upon decomposition of the latter appears native. It occurs partly as fine gold, partly coarse, and is found either directly imbedded in the quartz or contained in small cavities. Below the depth of 80 feet the pyrite is fresh. During 1870 the average yield of ore per ton is said to have been $75, sometimes running much higher, however.

The ore from the Cariso was crushed in a five-stamp mill, located on Willow Creek, about a mile below South Pass City.

Young America.

A few hundred feet east of the Cariso the Young America is located. It retains the same strike and dip as the former, and appears to be a continuation of the same vein. A shaft 128 feet in depth has been sunk, and some work was formerly done there. At the time of my visit no work had been done for some time, and the mine was inaccessible. Judging from the ore on the dumps, the gangue-rock consists of quartz very much splintered. Decomposed pyrite produces a red and brown color in it. I was informed that the ore carried a considerable quantity of silver, and paid about $25 per ton.

Wild Irishman.

This vein is located a short distance west of the Cariso. It trends in the same direction, and is conformable to the structure of the schists. At present it is abandoned. It appears that toward the west the vein splits, admitting a horse composed of gneissic and syenitic schist. I could not fully determine whether the Wild Irishman is a continuation of the Cariso, owing to the fact that the surface is obscured and the workings not accessible.

Some of the lodes in this vicinity, not worked, however, are the *Washington*, *Grecian Bend*, *Flora*, *Duncan*, and others.

Atlantic City is situated on the stage-road from South Pass to Camp Stambaugh. Originally of not as much importance as the former, it has lost less by the decline of mining operations.

Buckeye Mine.

This mine is located about a mile to the northwest of the town. It was discovered February 18, 1867, by "Judge" Lawn. The present owners are Messrs. Lawn, McBurk, and Dawkins. The mine is located on the north side of a steep gulch, near the summit of a narrow ridge. A partial caving in of the lower drift, and water in the shaft, made it impossible to visit all the workings. Syenitic schist is the country-rock striking nearly east and west at this locality. The schists are thinly bedded, sometimes contain mica, and then are laminated. Curves and ramifications are shown in the vein. Its strike is north 30° east, nearly at right angles to that of the schists. So far as could be determined, the

general dip is about 78° to the southeast, varying somewhat, however. A well-timbered shaft has been sunk through the unproductive rock, which struck the vein at a depth of 70 feet. From that point it follows the latter on the incline for 145 feet. A tunnel, driven from the southeast, also strikes the vein and connects with the shaft. Some stoping has been done here. Near the shaft a wide quarry was laid in the vein, and large masses of ore taken out. At this point the Buckeye receives a branch vein. Secondary quartz veins traverse the lode in various directions. It may be observed that the course of the latter is parallel to the main system of joints in the schists. On the hanging wall a well-defined clay selvage separates the ore from the country rock. This is less defined on the foot-wall. Both walls are firm. At several places lateral spurs leave the vein, running parallel with a second system of joints.

The gangue is composed of gray and white quartz, more or less discolored by the decomposition of pyrite. Throughout this gangue we find disseminated minute crystals of pyrite and fine gold. Decomposition of the former has freed the latter. At the depth reached by the workings up to the present time, no fresh ore has been obtained as yet, all of it being surface-ore. An extensive series of fissures occurs in the gangue, rendering it easy to work. During the past ten years much gold has been taken out of this mine, and the owners expected to start work again within a short time. A width of 4 to 14 feet shown by the vein guarantees to them an almost unlimited supply of ore.

Souls and Perkins Mine.

Opposite the Buckeye, on the south side of the gulch, the Souls and Perkins lode is located. It has approximately the same course, striking about north 8° east. Bearing the same relations to the surrounding schists as the Buckeye, its slight deviation is accounted for by the fact that the course of the schists undergoes some change. I regard the two locations as made upon one vein, although the connection is apparently broken. The Souls and Perkins is worked by means of a shaft which has been sunk to a depth of about 100 feet on the foot-wall, following the dip of the vein. Mineralogically the ore is the same as that of the Buckeye, but I have no data whereupon to base a comparison of their respective values.

Caribou Mine.

This mine is located on the northern extension of the Buckeye, about quarter of a mile distant. In dip and strike, the two are conformable, as well as in the general character of their ore. A shaft of a little over 100 feet in depth has been sunk on the vien, inclining with the dip. No work was being done on either of these two mines during the time of my visit, but the owners were anticipating "better times."

Miner's Delight.—This settlement is located about 2 miles north of Camp Stambaugh, and was started at the time of the great mining excitement during 1867. Comparatively little vein-mining is carried on here at present, as heretofore the gulches have yielded a good deal of gold. The Miner's Delight Mine is the only one worked at the present time. The entire claim is separated into three divisions, which have received special names.

Young America.

This mine forms the eastern extension of the vein. The strike of the entire vein is north 43° east, with a dip of about 80° to the southeast.

Gneissic schists compose the country rock. It is distinctly bedded, and its strata are cut at an acute angle, amounting to about 26° near the vein. A shaft 105 feet in depth has been sunk on the vein. At a depth of 60 feet a drift has been cut toward the west. The width of the vein varies from 1 foot to 4 feet. This is due to undulations in the hanging wall. Yellow and white quartz composes the gangue, containing free gold either in scales or as "fine gold." A mill with 20 stamps crushes the ore obtained from this portion of the vein. It is said to run about $15 to $20 per ton; but richer ore is expected in some new openings.

Miner's Delight.

The middle portion of the vein has received this name. In its position and associations it conforms to the Young America. A shaft 145 feet in depth has been sunk, and some interior developments have been made. At the time of my visit, buildings and machinery upon the surface had been completed, and it was stated that work would soon be actively resumed.

Western Extension.

This is the third portion of the entire vein. It is not worked at present. Upon the vein a shaft has been sunk 100 feet in depth. A 20-stamp mill located on the premises formerly crushed the ore, but now lies idle. The character of the vein and ore remains constant throughout the entire length, 1,600 feet. Occasionally pockets are found that pay very well. To the depths which have at present been reached, the ore is all more or less decomposed, yielding but little fresh pyrite. Some silver enters the bullion, as I was informed. This, too, must be contained in pyrite, as no specific argentiferous mineral is found in the vein. While working from the surface, which was a cheap process, large quantities of gold were taken from this lode.

Reviewing briefly the character of the Sweetwater gold-mines, we find that there are both true fissure veins and veins which form an integral portion of the prevailing schists. The great age of the latter and their physical structure has been the cause of extensive decomposition of the ore downward. Water entering through joints and fissures, together with atmospheric air, have produced a conversion of the pyrite into limonite, thus freeing the gold. From experience obtained throughout this class of veins, we may say that the immediate surface-ores are richer, as a rule, than those found at greater depths. So far as the work in the various mines of this region extends, however, it appears that even at considerable depths the ore contains a sufficiently high percentage of gold to make it remunerative if worked judiciously. I can see no reason why, under proper management, and with an application of experience gained elsewhere, many of these mines should not prove to pay upon working. We may assume that the decomposed ores extend to a depth of at least 150 feet. Their extraction and the process of obtaining the gold out of them is both cheap and simple. In case the ore should prove refractory lower down, methods are at hand to overcome the difficulty. By crushing, concentrating, and amalgamating the surface ores, good results ought to be obtained. Eventually roasting, or, if the character of the ore should change, smelting may be employed in the process of gaining the precious metal. For a number of years the mines which may now be regarded as most promising can be worked without much expense, as the location and class of ore at present eliminate nearly altogether the item of transportation.

It seems as if a new start were just now to be made, and it is to be hoped that careful management and proper treatment of the ores will demonstrate the fact that these metalliferous veins are entitled to some consideration.

Seminole Hills.—Near Sandy Creek, on the eastern slope of the Seminole Hills, gold mining was carried on for a short time several years ago. All the mines are now abandoned and could not be examined. The veins, upon which some work was expended, are quartzose, and run through the metamorphic granites of this region. From the ore found on some old dumps it was seen that it consisted of pyrite and chalcopyrite intimately associated with quartz. A stamp-mill and a number of other buildings have been erected on Sandy Creek, but are now left to decay. So far as we could learn, the ore when first struck was quite rich and promised excellent results. A company was formed to work and mill the product of the mines, but after a brief experiment it was found that the rich ore had merely formed a "pocket," and that its continuation did not pay. The mines were therefore abandoned, and no work has been done there for a number of years.

GULCH-MINING.

Near South Pass City.

Gulch-mining is carried on with varying success in the vicinity of the Sweetwater. Early during the summer season a considerable number of streams that later are dry contain a good supply of water. During that time it is utilized for the purposes of washing out the gravel and "dirt." Near South Pass City some washing is done on several small creeks. At the time I was there a good "prospect" had been struck on Willow Creek, within the limits of the town. In *Cariso* gulch sluicing and washing has been carried on for a number of years. The creek there is dry during several months, and water is supplied by a ditch, two miles in length, which connects with Willow Creek. It is stated that the miners obtained from \$3 to \$5 of gold per day. In *Hermit* gulch, and several others, gold is washed to a small extent. The trouble that miners have to contend with in this region is the want of water. As a rule, they can work only one or two months during the year in the majority of the gulches.

Near Atlantic City.

In the *Buckeye* gulch a large amount of work has been done during the past year. Two small dams have been constructed to regulate, if possible, the supply of water. Several small deposits were being washed during July, but the water was beginning to get low. The gold is found, generally, in very minute flakes, and unless precautions are taken will float off on the water. Coarse gold is comparatively rare.

Near Camp Stambaugh.

In the vicinity of Camp Stambaugh I saw more work going on than at any other point. On *Rock Creek* extensive preparations were being made to wash the gravel by hydraulic power. Ditches to lead the water to convenient points, and others to carry it off, had been constructed. Gulch-mining has been carried on there for a number of years on a small scale, but the miners proposed to obtain larger profits in the future than heretofore. A good water supply promises the carrying on of work

during several months. In *Strawberry Gulch* several miners were engaged in washing "dirt." Having found better pay about two miles distant, where there was no water, however, the gravel was carried over to the Strawberry and there washed. The miners appear to be satisfied with the results obtained. *French Gulch*, in the immediate vicinity of the post, has been worked for several years. A hose 600 feet in length and 6 inches in diameter tapped the creek, giving it a head of about 35 feet. The nozzle was an inch and a half in diameter. With this appliance the washing-down of gravel banks was rapidly accomplished. Gold was caught in a long sluice-box. Here the gold was somewhat coarser than is usually the case. On several other small streams near the post, gold was washed, but the water supply soon gave out. Most of the gravel will furnish "colors" upon panning, but it requires careful manipulation to save the metal.

Near Miner's Delight.

In the neighborhood of this town a large number of gulches have been and are worked. Prominent among them is *Spring Gulch.* The gravel is rather coarse, loosely cemented, and contains an appreciable quantity of coarse gold. It is stated that miners here wash out $6 to $7 per day. All the work is carried on, on a comparatively small scale. Other placiers that have been worked in this vicinity are *Meadow, Promise, Irish*, and *Beaver Gulches. Horace Gulch* is considered as one of great promise. *Twin Gulch* is supplied with water by a ditch several miles in length, and is said to yield good results.

From the observations which I made while examining this region, I am persuaded that a large amount of gold exists in the various deposits of drift and "dirt." It seems, however, that the washing of small quantities, with an insufficient supply of water, prevents the gulches from proving generally remunerative. Were it possible to obtain an adequate water-supply, and to carry on the work on a large scale during the entire length of the open season, I have no doubt that placier-mining would here be a paying operation. The gold which we find so widely distributed has been carried downward from the more elevated regions. It has collected in all such places where we would naturally expect to find either fluviatile or local glacial drift. So far as can be determined, the original places of deposition of the metal are to be looked for in the outcrops of auriferous veins. Decomposition has set the gold free there, and erosive agents have removed it to such localities where it could most conveniently accumulate.

SILVER.

Argentiferous veins have been reported as occurring on the western slope of the Wind River Range. So far as I am able to determine, this report is not founded upon facts. We observed, while surveying that region, a number of veins of varying size containing specular hematite. It closely resembles some of the silver-bearing minerals, and its occurrence has probably given rise to the current rumors. Upon examination of several specimens, either no silver or merely a trace of it was found. From the features that we have noted in connection with the archæan as well as metamorphic area of the entire region, we are justified in concluding that no prominent systems of metalliferous veins will be found anywhere except in the old schists where they have already been discovered. The term "metalliferous" is here used with special reference to gold and silver. Wherever lodes have been found they obey

certain rules, within restricted areas. What we have learned with regard to the character, association, and distribution of the lodes of the Shoshone and Miner's Delight districts entitles us to the opinion above expressed.

IRON.

The most important deposit of iron within our district is found near Rawlings Springs. About two miles north of the town is located what is known as the *Red Paint Mine.* This is an open quarry in an extensive deposit of red hematite. Its commercial value, either as paint, flux, or ore, renders it of importance. Along the line of the Union Pacific Railroad a number of such deposits have been found, and they are utilized for the purposes above mentioned. The hematite at Rawlins is contained in a Palæozoic series. It is remarkably pure and free from quartz.

In the main chain of the Wind River Mountains a number of veins were observed in the granite containing specular hematite. Usually this is associated with chlorite and some hornblende. From the thickness of a knitting-needle the seams containing this mineral widen out to veins of several feet. Interesting as these occurrences are, the demand for iron will never be sufficiently great to give them any value.

A few miles south of Atlantic City a vein of siderite is located. It is known as *Heyroth's lode.* Traversing the schists, this lode maintains a width of from 2 to 4 feet. The siderite is changed into limonite near the surface, but lower down is not decomposed. It contains an admixture of clay, which renders it somewhat impure.

At several localities within the Cretaceous and younger groups, small deposits of limonite were seen. They are parallel to the stratification, and will scarcely ever prove to be of any value. "Kidney-ore" was found in the Post-cretaceous series, associated with coal.

GRAPHITE.

Near Miner's Delight a vein containing graphite is said to be located. Without obtaining a guide, I endeavored to find it, but failed. Not having been able to see any of the specimens said to occur in this vein, I am unable to give any opinion upon it. Persons who have seen them assure me that it "writes as well as a lead-pencil." This may or may not be regarded as a crucial test. So far as I could understand, the supposed vein is found in the metamorphic rocks of that region.

COAL.

A large portion of the area surveyed shows the Lignitic formation of the West. At a number of places along the Union Pacific Railroad, openings have been made from which coal was obtained. Near Rawlings Springs is one mine which is worked during a portion of the year at least. Farther west there are others which now are abandoned. The extensive veins near Point of Rocks, Evanston, and other places, supply the demand, and no chance remains for individual enterprise along the line of the road. Numerous outcrops were observed, some of them indicating veins of considerable size. North of the Sweetwater Hills I saw no workable beds, although it is claimed that some have been discovered. The coal found within our district is of that variety which is generally termed "lignite." It is of good quality for ordinary purposes, and is extensively used west of the Missouri River. Certain banks contain less ash than others, and again beds may be found that will form a hard,

compact coke. These are preferred for smelting and other processes. In my report on the coal region of Evanston I shall have occasion to enter into the details of composition and economic utility of these coals more fully than could here be done.

LIMESTONE.

On the eastern slope of the Wind River Mountains, in the Sweetwater and Seminole Hills and near Rawlings, limestones are abundant. At the first-named locality the admixture of silica generally renders them impure, but some strata can be found that are comparatively free from it. Within easy reach of the settlements, these beds may at some future time prove serviceable. Excepting the silica, they are sufficiently pure and almost quite free from alumina. Within the same regions some beds may be found that could be utilized as marble. They occur near the base of the Carboniferous series. In the Sweetwater and Seminole Hills the limestones show essentially the same characteristics, but contain, perhaps, less silica. On the eastern slope of Rawlings Peak strata composed of this material occupy a very prominent position. I am informed that some lime is burned in that vicinity, and that the quality obtained is good. Along the western slope of the range and south of the Sweetwater Hills limestones occur, but they are very impure, approaching more closely in character calcareous shales.

GYPSUM.

This mineral occurs most abundantly in the lower portion of the Triassic beds. Below the junction of Twin Creek and the Little Popo-Agie I noticed the most extensive exposures. Beds were there found reaching a thickness of several feet. Generally this gypsum is light red, gray, or yellow, but white strata can be found. It is crystalline rather than compact, resembling alabaster in texture. Some of the beds would furnish excellent material for purposes of carved ornamentation. Fibrous gypsum (satin-spar) is found together with the other, occurring in narrow seams and veins cutting across the strata. As gypsum is essentially a local deposit, the thickness of the beds varies considerably at different localities. Near the Popo-Agie settlements, however, there is an ample supply for all purposes. Throughout the formations composed in a great measure of shales we find crystals of selenite. Mostly they are quite small, but they occur in tablets of several inches in thickness and a foot in diameter. Among all others, the Wasatch Group may be regarded as the one most highly favored in this respect.

CEMENT.

Many of the shales and marls which occur in the Cretaceous and Tertiary Groups would answer very well for the manufacture of ordinary and hydraulic cement. Within the Sweetwater Group there are some strata that could be used for these purposes with but slight preparation. Many of the marls are arenaceous, but if such were selected that are comparatively free from sand they could be utilized. It is not probable that ever any very great demand for cements will arise in that section of country, and the expenses of transportation would most likely prove to be too heavy to realize profits by shipment. It is well, however, to know that the materials are at hand to render the inhabitants independent in the matter of cements, which often may become an important question.

CLAY.

As a rule, the accumulations of clay are too sandy to be used for other purposes than that of manufacturing adobe or brick. In some of the dry alkali flats clay may be found, however, which would answer very well for the preparation of stone-ware and pottery. If too great an admixture of alkali be found with the clay, this can readily be removed by a process of washing.

ALKALI.

Under this very general term we comprise a series of products, all of which represent a certain commercial value. "Alkaline" deposits are found very frequently within our district. They occur in great profusion throughout the low country south of the Sweetwater Hills. Along the Sweetwater River and in the low country northward they are met with. No thick deposits of such substances were found, but it is probable that they occur in certain regions at some inconsiderable depth.

From the annual report of 1870 I extract a number of analyses of alkaline efflorescences collected within our district and examined by A. S. Ford.*

1. From alkaline lake two miles east of Rock Independence:

	Per cent.
Sulphate of soda ($Na\,O\,S\,O_3$)	73. 17
Chloride of sodium ($Na\,Cl$)	3. 85
Carbonate of soda (by loss)	22. 98
	100. 00

2. Alkaline efflorescence seven miles west of Saint Mary's Station, in Sweetwater Valley:

	Per cent.
Sulphate of soda ($Na\,O\,S\,O_3$)	88. 93
Chloride of sodium ($Na\,Cl$)	11. 63
	100. 56

3. From deposit near Pacific Springs:

	Per cent.
Sulphate of soda ($Na\,O\,S\,O_3$)	82. 23
Chloride of sodium ($Na\,Cl$)	3. 95
Carbonate of soda (by loss)	14. 82
	100. 00

4. From deposit of alkaline pond near Big Sandy River:

4 (*a*). From upper part of bank where deposition commenced:

	Per cent.
Sulphate of soda ($Na\,O\,S\,O_3$)	64. 65
Chloride of sodium ($Na\,Cl$)	35. 46
	100. 11

4 (*b*). From half-way between upper and lower limit of deposit:

	Per cent.
Sulphate of soda ($Na\,O\,S\,O_3$)	94. 92
Chloride of sodinm ($Na\,Cl$)	5. 23
	100. 15

4 (*c*). From lowest part of pond:

	Per cent.
Sulphate of soda ($Na\,O\,S\,O_3$)	100. 00

According to Mr. Ford's statement, this last deposit occurred in the form of slender orthorhombic prisms. Potassium was not found in combination with any of the acids or with chlorine in these deposits.

*The analyses are directly copied, giving the old formulæ.—E.

From these analyses it appears that we have in solution mainly two minerals: *Halite* (salt) and *Thenandite* (sodium sulphate). A third one is the *Trona*. Dr. Heizmann mentions, in addition to these, lime and magnesia.

The predominance of sodium sulphate is an interesting feature, and has a direct bearing upon the genesis of these compounds. We are aware of the fact that many of the shales and marls from which the alkali is derived contain minute crystals or small seams of pyrite. Upon the decomposition of both shales or marls and the pyrite, the liberated sulphur of the latter combines as sulphuric acid with the soda, or, in some instances, magnesia, which has been set free from the shales. Thus the substance which is found in the greatest quantities is formed. Although magnesium sulphate appears to occur but sparingly in the region through which we traveled, it has been found elsewhere in large deposits, which occupy positions analogous to those in which we observe our "alkali flats."

PETROLEUM.

Two localities were visited in our district where springs of petroleum occur. One spring is located on the Little Popo-Agie. It is quite extensive, and in the course of years has emitted a large quantity of oil. The other one is situated near Camp Brown, and issues together with water. No means were at hand either to test the oil on the spot or to carry it with us. Therefore the only examination that could be made consisted in the simple trial of burning it. Taking some of the hardened material, we found that it burned with a bright flame, and that nearly all of it was consumed. I am not prepared to say that the composition of this oil is identical with that occurring in Pennsylvania, for instance, but I am of the opinion that by distillation a product might be obtained which would answer for the purposes of illumination. In the course of time these springs may prove to be valuable, as their location renders them accessible to that portion of our district which offers the most varied and the greatest inducements to settlers.

CONCLUSION.

Several features of great interest were observed in the Sweetwater district. Prominent among these is that pertaining to the elevation of mountain ranges and to great stratigraphical disturbances generally. Represented by the Wind River Mountains we have a portion of the main Rocky Mountain system. The structure of this range is essentially simple. It is the direct product of an unequal anticlinal fold. Studying the position where it is located, we observe some important facts. To the north and northeast of the range the older sedimentary formations rapidly assume very great vertical dimensions, while for a long distance in the opposite direction they show a smaller development. Here, then, we find an area of maximum sedimentation—one capable of producing the results which Sir John Herschel so ingeniously assumes, *i. e.*, a downward flexure of the strata. This necessitates a corresponding upward movement in order to re-establish equilibrium. Such a movement will take place at the point or along the line of minimum resistance. In the existence of the Prozoic subsidiary range we have an ancient barrier to the influx of the earliest waters producing sedimentation; consequently we find along this old range a line least incumbered by deposition of weighty sediment. This indicates the horizontal zone of least vertical resistance, and here we find the Wind River Range occupying a very elevated position. From the structure of these mountains, as well as from that of the sedimentary area east and northeast, we learn that the force which produced the upheaval made itself felt for a greater distance eastward than west. This is shown by the long-continued easterly dip of the strata and by the subsequent rearrangement of strata as produced by the two easterly anticlinal uplifts. A result of this nature would necessarily follow were the cause of the first disturbance located north and northeast of the range. We observe in the range, as well as in the anticlinal folds eastward, the lack of symmetrical arrangement of participating beds. The axes of the folds, instead of standing vertical, incline to the northeast, at angles from 20° to 30° from the vertical. Expressing the same fact in other words, we may say the movement producing the elevation of ridges or ranges which show an anticlinal structure has, in this instance, progressed from northeast to southwest, and, we may add, due to the influence of endogenous flexure of deposits caused by an enormous accumulation of sediment.

As the two anticlinal folds which have been marked as A and B in previous pages approach the Sweetwater and Seminole Hills, the direction of the vertical axis changes. It becomes first perpendicular, and then inclines to the southwest. This, no doubt, is owing to the existence primarily of granites, which, in that region, have been elevated synchronously or immediately before; and, secondarily, to the masses of sediment which had an opportunity to accumulate to the southward. In connection with the remaining two anticlinals of our district (C and D), we observe the same features that have been seen occurring near the Wind River Range. The strata involved show a more rapid inclination toward the west than the east. So far as the area which we examined is concerned, we may regard it as a rule that the axes of anticlinal folds trending north and south, with variations to the northwest, show a decided dip to the east and northeast. It is a matter of some risk to base generalizations upon observations extending over even more than 10,000 miles. I am fully aware that investigations of contiguous regions may prove the views held with regard to the elevation of the Wind River chain as untenable. The above demonstration, however, has suggested

itself to me while prosecuting the study of this district, and I believe that eventually it will be found to be correct.

Concerning the geological period during which the main range was elevated, we have obtained some data, which, to me, appear conclusive. The general easterly and northeasterly dip of the older sedimentary formations at the base of the mountains is established. We have traced the series, one conformable upon the other, from the Silurian to the Tertiary, and have recognized the representative of the Eocene, the Wasatch Group. Uncomformably overlying this last-named member we observe the Sweetwater Group. Whatever may be the position in systematic classification to which this is assigned, it is certainly considerably younger than the Wasatch. This, therefore, is an instance, where an Eocene Group, disturbed from its original, horizontal position by the elevation of the main range and its accompanying upheavals, fails to remain conformable with a younger Miocene Group. Consequently, we must regard the period of elevation as falling between the Eocene and the termination of the Miocene. The exact chronological position it occupies is not apparent, but so much can be said with certainty, that the Wind River Range was elevated after the deposition of the Wasatch Series, and reached high altitudes before the deposition of the Sweetwater Group. A slight dip of the beds composing the latter, as well as of the Pliocene beds covering them, could be observed throughout their exposure. This indicates a general minor elevation, subsequent to the Miocene period, along a curving line which essentially forms a continuation of the longitudinal axis of the range. The vertical extent of this gradual rise was comparatively inconsiderable, as the inclination of strata reaches a maximum of only 5°.

From the evidence which could be obtained, I regard the formation of the anticlinal folds east of the range as subsequent to the elevation of the mountains. After they had come to a point of stability, the gentle rise above mentioned took place. These observations confirm the views held by Dr. A. C. Peale, presented in the American Journal of Science and Arts, April, 1877.

It will be remembered that the anticlinal uplift near Salt Wells (*D* in Section XVII) trends west of south. At nearly right angles to this, south of east, we observe the strike of the leucitic eruptions. Nearly all of the lava has been poured out through fissures. We may readily, therefore, assume a causal connection between the two phenomena.

Sedimentary formations are amply represented in our district and are studied with great ease. Typical in every respect, they offer very little difficulty as to identification. Although they take an active part in all the dynamical disturbances of the region, their original position, as well as present connection, can be traced without much trouble. Some hesitancy is experienced in classifying the various groups of the Tertiary formation, as but a portion of the entire series occurs. In the preceding report this has been done in such a manner as is warranted by the observations made in the field. Palæontological remains are comparitively rare, but enough were found to enable subdivision of formations into their respective groups.

An attempt has been made to classify the Archæan rocks with some degree of accuracy. The region is favorable to this purpose, and the relations of the groups, among themselves, are definite. In the appended table they have been placed on a parallel with eastern systems, but it is not intended that an absolute identity should thereby be expressed. Relatively, they occupy the same positions west as east, but are not precisely either the same in composition or arrangement of beds.

TABLE OF FORMATIONS.

A table has been prepared enumerating the various formations and groups as found in the Sweetwater district. The thickness of groups have been given from the minimum to maximum, and it has been indicated in which portion of the district the latter is found. Generic names of the fossils observed have been introduced.

Table enumerating the various formations and groups as found in the Sweetwater district.

Class.	Formation.	Division.	Group.	Fossils.	Character of strata.	Thickness in feet.
CENOZOIC.	QUARTERNARY.	UPPER.			Sand dunes, soil, loose drift and gravel ..	Varying.
		LOWER.		Shells of living *Gasteropods* in lake beds.	Lake beds, glacial deposits, and old river drift.	Varying.
	TERTIARY.	PLIOCENE.	*Wyoming Conglomerate.*		Loose, structureless conglomerate. Spread over the undisturbed younger beds.	10 to 400
			Niobrara Group.	Numerous remains of *Mammals.*	White, light yellow, pink, and greenish marls and sands. Some beds of sandstone near base.	300 to 900
		MIOCENE.	*Sweetwater Group.*		Local deposit. Brown indurated shales and marls, some sandstone and couglomerate near base.	1200 to 1400
			Bridger Group.	Numerous remains of *Turtles, Limnæ*, &c.	White, light gray, and buff calcareous shales and marls; series incomplete.	500
			Green River Group.	*Fishes* and *Insects* in shales. Plants higher up.	Brown, concretionary sandstones near top. Blue, gray, and white calcareous shales lower down. Carbonaceous shales, sandstones, and dark shales near base. Thinning northeast.	1700 to 1800
		EOCENE.	*Upper Wasatch Group.*	*Leaves* in the sandstones and some of the shales.	Massive sandstones and shales. Red near top. Shales yellow and brown, containing selenite. Basalt breaking through them. Coal.	600 to 650
			Lower Wasatch Group.		Highly arenaceous marls. White, yellow, green, red, brown, and maroon. Sandstones near base, together with heavy local conglomerates. Thinning out northward.	600 to 700

Table enumerating the various formations and groups, &c.—Continued.

Class.	Formation.	Division.	Group.	Fossils.	Character of strata.	Thickness in feet.
MESOZOIC.	POST-CRETACEOUS.	LARAMIE.	*Laramie Group.*	Numerous *Leaves*. Invertebrates of fresh-water and brackish-water types. *Ostrea, Viviparus, Unio, Goniobasis*, &c.	Series of shales and sandstones. Coal near the top and near base. Clays and shales in vicinity of coal. Thinning out northward, and incomplete there.	1600
	CRETACEOUS.	NOS. 4 AND 5.	*Fox Hills Group.*	*Inoceramus, Ostrea*, and numerous other *Invertebrates*.	Sandstones and shales near the top, containing coal. Massive arenaceous and micaceous shales lower down. Shales and sandstones at base. Thinner northward.	500 to 1300
		NOS. 2 AND 3.	*Colorado Group.*	*Inoceramus, Ostrea*, and other *Invertebrates*.	Sandstones at top. Massive dark-gray shales, weathering light gray and white. Carbonaceous shales. Thinner toward north.	600 to 850
		NO. 1.	*Dakota Group.*	*Leaves, Gryphæa, Inoceramus*, and other fossils.	Massive yellow and white sandstones, with carbonaceous shales. Gray, yellow, and brown shales. Sandstones and conglomerates near base. Thinner northward.	600 to 700
	JURA.	VARIEGATED BEDS.		*Belemnites, Gryphæa, Pecten*, and other *Invertebrates*.	White, yellow, pink, and light-green marls at top. Yellow shales, with limestones, lower down. Massive blue limestones near base. Thicker north.	120 to 220
	TRIAS.	RED BEDS.	*Upper.*		White, yellow, and pink coarse-grained sandstones. Thin beds of shales between them.	150 to 400
			Lower.	*Natica* in dolomitic limestones. *Fucoid* forms in sandstones.	Massive red argillaceous sandstones. Red shales, with dolomitic limestones, in the middle. Red and pink sandstones, with gypsum, near base. Thicker northward.	600 to 800
PALÆOZOIC.	CARBONIFEROUS.	UPPER.	*Permian Group.*	Indistinct remains of *Plants*.	Pink and yellow sandstones, with yellow and greenish shales. Ripple-marks.	150 to 320
		MIDDLE.	*Carboniferous Group.*	*Productus, Orthoceras, Orthis*, and other fossils, all silicified in the northern portions of the district.	Massive blue limestone, containing large quantities of concretionary silica. Toward the base some magnesian limestones. Thicker toward the north.	1400 to 2200
		LOWER.	*Subcarboniferous Group.*	*Crinoids, Corals, Chonetes, Spirifer, Orthis, Orthoceras, Productus*, and others, mostly silicified.	Dolomitic limestones, yellow and gray dolomites, with some sandstones near top. Thicker northward.	350 to 700

Table enumerating the various formations and groups, &c.—Continued.

Class.	Formation.	Division.	Group.	Fossils.	Character of strata.	Thickness in feet.
PALÆOZOIC.	SILURIAN.	UPPER.	*Calciferous Group.*	*Orthistritonia*, *Corals*, *Dicellocephalus*, and others.	Blue and white limestones, partly oölitic. Thinly banded shales. Greatest thickness north.	100 to 280
		LOWER.	*Potsdam Group.*	*Lingula, Obolus, Obolella*	White and yellow, mostly red quartzites. Sometimes thinly bedded, and again heavily stratified. Greatest local development at Rawlings.	220 to 600
ARCHÆAN.			*Huronian System.*		Granites, composed of orthoclase, oligoclase, quartz, and dark-colored micas. The latter substituted by hornblende and chlorite.	30, 000
			Laurentian System.		Schists, composed of quartz, feldspar, hornblende, and mica. Metaliferous.	18, 000
			Prozoic System.		Massive, structureless granites, composed of orthoclase, large masses of white quartz and muscovite.	Indefinite.

We find that in the Sweetwater district the total maximum thickness of sedimentary deposits amounts to more than 16,000 feet. The estimates upon which the thickness of Archæan groups are based must necessarily be incomplete, but I believe that the figures given approach to true dimensions as closely as is possible. Were the structure of chains and ranges perfectly open, more reliable results could be obtained.

APPENDIX.

CATALOGUE OF MINERALS OCCURRING IN THE SWEETWATER DISTRICT.

The catalogue herewith presented is a very meagre one considering the area over which our explorations extended. This is due, in part, to the fact that but a very small portion of the area was composed of mineral-bearing rocks, and partly to the fact we have no time to search systematically for them. It was my intention to prepare a catalogue covering the entire territory, but the requisite information upon the subject of distribution of mineral species does either not exist or is not available. Whenever the necessary amount of material may have been collected for such a purpose in a manner that it may be utilized, I propose to carry out my original plan.

AMPHIBOLITE.—Small crystals in the hornblendic schists of the metalliferous series. Green, partly fibrous, in granitic syenite near Rawlings.

AUGITE.—Minute crystals in the basalt near Essex Mountain. Found also in some of the basalts northwest of Salt Wells.

AZURITE.—The result of decomposition of chalcopyrite in Seminole Mines.

BIOTITE.—Small, six-sided crystals in basalts. Together with augite.

CALCITE.—Crystallized in small fissures and druses of Carboniferous limestone. On Beaver Creek, along the eastern base of Wind River Mountains, and in Seminole Hills. Scalenohedra, rhombohedra, and combinations of both, are found.

CHALCOPYRITE.—Small quantities in the mines of Seminole Hills and of South Pass City.

CHLORITE.—In some of the granites of the Wind River Range.

COAL.—Bituminous coal occurs in the Laramie and Wasatch Groups. Is mined extensively at Rock Springs, Evanston, and other localities.

CORUNDUM.—Small particles in some of the high granites of the Wind River Range.

EPIDOTE.—Crystallized and massive in the metamorphic granites of the Wind River Range.

GLAUBERITE.—In small quantities in some of the "alkali-flats" as efflorescence.

GOLD.—In the Sweetwater Mines, Seminole Mines, and other localities. In numerous gulches and in quartz veins.

GYPSUM.—Massive in the lower beds of the Triassic formation. Good exposures found on the Little Popo-Agie.

Alabaster.—At the same locality, white, yellow, and red, either pure in color or veined.

Selenite.—Throughout the Wasatch shales and marls. Single and twin crystals. Found in many shales, irrespective of groups.

HALITE.—Found in the alkaline efflorescences of dry lakes.

HEMATITE.—Massive, red in the Palæozoic rocks near Rawlings Springs. Utilized as flux for ores and as red paint.

Fibrous.—At the same locality.

Micaceous.—In some veins traversing the granites of the Wind River Range on the upper drainage of the Little Sandy.

Specular.—At the same locality. Occurring mostly in small, crystalline masses, rarely crystallized.

LIMONITE.—In Cretaceous shales on the Little Popo-Agie. Throughout the ferruginous strata of the upper Cretaceous beds, in small deposits.

MAGNETITE.—Minute crystals in some of the metamorphic rocks.

MALACHITE.—In chalcopyrite, the result of decomposition from ore of the Seminole Mines.

MUSCOVITE.—Good crystals in granite east of the South Pass. Throughout the Prozoic granites, sometimes in sheets of several inches.

OBSIDIAN.—Scattering, in fragments, transported from other localities by Indians.

OLIGOCLASE.—In the granites of the Wind River Range. Rarely occurring crystallized.

OLIVINE.—In some of the basalts near Essex Mountain.

ORTHOCLASE.—Red and flesh-colored in the Prozoic granites. No crystals were found.

PETROLEUM.—In the "tar springs" of the Little Popo-Agie and near Camp Brown.

PHLOGOPITE.—In the granites of the Wind River Range, as a constituent mineral.

PYRITE.—Throughout the Sweetwater Mines. Mostly decomposed. Crystallizes in cubes. In the Seminole Mines. Concretionary in the shales of the younger sedimentary groups.

QUARTZ.—Crystallized in druses of the Carboniferous limestones. Massive; white, yellow, gray, and pink in the Prozoic and metamorphic granites.

Agate.—In the lower Green River and upper Wasatch beds. Forms geodes in Carboniferous limestones.

Basanite.—In drift originating from Tertiary strata.

Chalcedony.—Very abundant in drift and in the upper strata of the Wasatch. Found in large quantities in the Carboniferous limestones and Pliocene marls north and northwest of Granite Hills.

Flint.—Occurs together with chalcedony.

Jasper.—Found at the same localities.

Moss-agate.—Very fine north of the Sweetwater, at Agate Lakes. Poorer specimens from the upper Wasatch beds.

SIDERITE.—Massive in the metalliferous schists south of Atlantic City.

THERNANDITE.—In the alkaline lake deposits as efflorescence. Sometimes crystallized.

TOURMALINE.—Good crystals, with double terminations, west of South Pass in granites.

TRONA.—In alkaline deposits as efflorescence.

WAVELLITE.—Radiated in shales near Separation. Light-green color.

ZIRCON.—In some of the hornblendic and micaceous schists near Camp Stambaugh.

REPORT OF C. A. WHITE, M. D.

LETTER OF TRANSMITTAL.

UNITED STATES GEOLOGICAL AND GEOGRAPHICAL
SURVEY OF THE TERRITORIES,
Washington, D. C., October 1, 1878.

SIR: I have the honor to transmit herewith the report of my paleonto-geological labors in the field for the season of 1877, together with other relevant matter illustrative of their results. The field-work assigned to me consisted of a series of special geological investigations, in which paleontological research should constitute a prominent feature. The regions or districts in which, in pursuance of this plan, I have prosecuted my investigations, have from time to time been more or less fully reported upon as to the stratigraphical geology, by various field geologists, but still the necessity existed of correlating the formations as found in those districts respectively, and upon both sides of the principal mountain ranges, by a careful collection and investigation of their fossils. While it was understood to be essential that all the formations which were traversed in my journeyings should receive careful study, it was thought especially desirable to investigate those strata on both sides of the Rocky Mountains, which lie between the Fox Hills Group of the Cretaceous series below and the Tertiary strata of exclusively fresh-water origin above. These strata are here designated as the great Laramie Group, and include those which have been designated, in the former publications of the Survey, as the Lignitic Group, east of the Rocky Mountains and in Middle Park, Colorado; the Bitter Creek series and their equivalents west of those mountains, especially in the great Green River basin; the so-called estuary beds of Bear River Valley, in Southwestern Wyoming and adjacent parts of Utah, and also the Judith River and Fort Union beds of the Upper Missouri region.

My report, having in part a narrative form, will supply all the desirable details of travel and field-labor, but the following statement of the general course of my travel during the season will aid in forming an idea of the geographical scope of my labors:

Outfitting at Cheyenne, Wyo., I journeyed southward, traversing in various directions a portion of the great plain that lies immediately adjacent to the eastern base of the Rocky Mountains. The most easterly point thus reached was some 60 miles east of the base of the mountains, and the most southerly point about 25 miles south of Denver, Colo. Returning to Denver for outfit-supplies I crossed the Rocky Mountains by way of Boulder Pass; thence through Middle Park and across the Park Range to the headwaters of Yampa River; thence down that river to a point about 20 miles west of the western base of the Park Range of mountains; thence southeastward to the White River Indian Agency; thence down White River valley about 100 miles; thence northwestward to the point where Green River makes its exit from the cañons of the Uinta Mountains. Crossing Green River at that point, I continued my journey westward, near the southern base of the Uinta Mountains, cross-

ing the Wasatch Range at its junction with that of the Uintas, to Great Salt Lake, the most westerly point of my travel. Recrossing the Wasatch upon the north side of the junction of the two ranges, I proceeded eastward, my general course lying between the northern base of the Uintas and the Union Pacific Railroad, and finally leaving the field on October 1, at Rawlins Station on that railroad.

Aside from accomplishing the special objects of the journey here outlined, I was enabled to spend considerable time in the district between Yampa and White rivers, making essential additions to the geological studies I had made there during the previous season, the results of which have been incorporated into my report for 1876, now in type.

In the discussions of the strata and fossil faunæ of each of the localities which I visited during this season, as well as in the more general discussions at the close of this report, I have made use not only of much information that I have obtained by former similar field labors, but also, for purposes of comparison, of much that has been done and published by others. Therefore the scope of this report is much greater than the results of the single season's labor in the field for 1877. Among this added material are some lists of fossils which have from time to time been sent to the office of the survey, by persons not officially connected with it, from various and distantly-separated localities in the western part of the national domain. By the use of these, in connection with other information, I present some interesting and important facts concerning the geographical distribution of invertebrate types, especially during the Cretaceous period.

While this season's work is seen to be only the beginning of a necessary series of similar field investigations, it is a matter for congratulation that so good a degree of progress has been made in the elucidation, upon the basis established as the result of your early labors in the western field, of the questions which they involve.

Very respectfully, yours,

C. A. WHITE.

Prof. F. V. HAYDEN,
In charge of the United States Geological Survey of the Territories.

REPORT ON THE PALEONTOLOGICAL FIELD-WORK FOR THE SEASON OF 1877.

By C. A. White, M. D.

The outfitting camp being located on Owl Creek, twelve miles south of Cheyenne, field examinations were begun in that neighborhood. This district is one of considerable importance from the fact that the southern boundary of the large region occupied by the deposits known as the White River Tertiary Group, probably of Miocene age, passes through it in an easterly and westerly direction. This formation is seen to rest directly upon the lignite-bearing strata of the Laramie Group; and although the strata of both formations are so nearly level here as to betray no unconformity of deposition, the two are known to be unconformable by sequence. In other words, certain Tertiary formations in the great Green River Basin west of the Rocky Mountains, are now known to belong in the geological series between the White River and Laramie Groups, although they are seen in contact in the region under discussion. No special examination of the White River Tertiary beds was made upon this occasion, except so far as to ascertain their general characteristics for immediate comparison with the Laramie Group, to which it was proposed to give especial attention. The White River formation is known to extend from the base of the mountains far out upon the great plains, and also far to the northward; and wherever these beds exist in the broad reigon thus indicated they cover those of the Laramie Group, and are believed to rest in all cases directly, although unconformably, upon them. In all the great plateau region west of the Rocky Mountain Range proper, the extensively eroded and deeply carved strata of the Mesozoic and Cenozoic formations are so perfectly denuded of the débris resulting from their erosion that scarcely any impediment exists to their complete and rapid study. Their investigation is still further facilitated by the sparsness of vegetation and the multitude of elevated points for observation left as a result of deep erosion before referred to. In the plains east of the mountains, however, even the same formations, retaining the same lithological characteristics as those western ones just mentioned, while they may have suffered much erosion in the aggregate, have been eroded less deeply. Therefore the débris resulting from their erosion is abundant upon the surface, and the free exposures of the undisturbed strata are compatively few, except where they are upturned against the immediate flank of the mountains. In that portion of the plains, however, which I examined in 1877, the exposures were sufficiently numerous, aided by the extreme simplicity of the stratigraphic structure of the region, to enable me to trace out the formations and to determine their characteristics, without difficulty.

The first exposures of the Laramie Group which I examined were at and in the vicinity of some abandoned coal-mines about two miles west of Maynard's Ranch, a few miles east of the foot-hills of the Rocky Mountains, and about twenty-five miles south of Cheyenne. The strata here are nearly level, or have only a slight dip to the eastward, and the

openings in the coal-bed have been made in a broad depression of the surface, or shallow valley, along a line a couple of miles in length and having a northerly and southerly trend. The rocks here, and in this vicinity, both of the Laramie and Fox Hills Groups, consist of soft sandstones and sandy shales, the latter apparently predominating, and among the strata of the Laramie Group there are occasional layers that contain a considerable amount of carbonaceous matter, besides the bed of coal before referred to.

In this neighborhood the only fossils obtained were from the Laramie Group, and with the exception of a single imperfect example of a *Corbula* probably *C. perundata* Meek and Hayden, they belong to one species each of *Ostrea* and *Anomia.* The latter is the *Anomia micronema* of Meek which is common but not abundant. The *Ostrea* was found to be quite abundant, especially in some places. They were found to occupy at least two layers of considerable constancy and extent and only a few feet apart. The principal oyster layer is between 50 and 100 feet above the bed of coal already mentioned. The position of the coal and the fossiliferous layers in relation to either the base or summit of the Laramie Group as it exists in this region could not be ascertained, but observations made both here and in the valley of Crow Creek, where the same layers were clearly recognized, seem to indicate that their position is nearer to the base than to the summit of the group as it is developed east of the Rocky Mountains. It may be remarked here in passing that the aggregate thickness of the Laramie Group is much less east of the mountains in Colorado than it is west of them in the great basin of Green River.

The shells of *Ostrea* found at the locality near Maynard's Ranch, like those of all the known species of that genus proper, are very variable, so much so that it would be impossible to represent the species (for I regard them as belonging to one species only) by the most careful selection of only a few examples. After a careful study of a large collection of these shells, made not only at this locality, but also in numerous other localities of the Laramie strata of this region east of the mountains, most of which are from substantially one and the same limited horizon, I am convinced that they constitute only one species, notwithstanding their great variation. A large proportion of the lighter, thinner, and more elongate shells, are plainly identical with those forms that were originally described by Meek and Hayden as *Ostrea glabra*, their examples having been obtained from the Judith River beds of the Upper Missouri River region. Others, among the larger aud more massive shells, are undistinguishable from *O. wyomingensis* Meek, as found at the typical locality at Point of Rocks Station, Union Pacific Railroad, in the valley of Bitter Creek, Wyoming. There are still others, small examples, that may reasonably be referred to those forms which Meek, in vol. ix of the United States Geological Survey of the Territories referred, and perhaps correctly, to *O. subtrigonalis* Evans & Shumard. Among the large collections of these shells that I have made in the region adjacent to the eastern base of the Rocky Mountains in Colorado, it is easy to select forms that will connect together all three of those that have just been mentioned, and which have been described as distinct species. Such selections and arrangement leave the differences between any of the varietal forms so employed far within the most rigid limits of recognized specific variation among the *Ostreidæ*. If this conclusion is correct, as it is believed to be, it not only shows an identity of three forms, hitherto supposed to be specifically distinct, but it also shows a very wide geographical distribution of the species, and a geological equivalency of

the strata in which they occur. But this subject will be discussed farther on in this report, in connection with facts of a similar nature in relation to other species also.

Going westwardly from the fossil and coal locality, in the neighborhood of Maynard's ranch, I passed the base of the foot-hills and went a few miles up "Box Elder Cañon," examining the strata of the different Mesozoic formations as they successively rise from beneath the Laramie Group and each other, and are upturned there against the flanks of the mountains.

Owing to the friable condition of all the Laramie strata, they have been mostly removed by erosion wherever they were formerly upturned. The formations that successively rise beneath these are, in the descending order, the Fox Hills, Colorado, and Dakota Groups, of Cretaceous age, and the "Red Beds," of supposed Triassic age, the latter resting directly upon the granite. In this vicinity I failed to find any fossils in any of the strata of these formations beneath the Laramie Group, but from the well-known lithological characteristics of each group respectively, they were readily identified. The strata of the Fox Hills and Colorado Groups, at least the upper portion of the latter, being like those of the Laramie Group, comparatively soft and easily eroded, the surface of the plains is continuous toward the mountains over these formations, the foot-hills of the mountains being composed mainly of the harder strata of the Dakota Group and the Red Beds. The lower portion of the Colorado Group is composed in this region of light-colored, firm, siliceous shales, which in some places are rocky enough to form hog-backs of considerable elevation. At no locality east of the mountains did I find the strata of the Colorado Group composed of the soft, blue, clayey shales that so generally characterize that group west of the mountains. In the last-named region, however, the lower portion of the Colorado Group is almost everywhere characterized by a greater or less thickness of bluish or dark fissile shales, which is perhaps only a modification of the more rocky portion, holding a similar position in the group east of the mountains.

From Box Elder Cañon I traversed the space between that point and Cache à la Poudre River, a tributary of the South Platte, which I reached opposite the town of Greeley, going by the way of Higley's coal-mine. I recognized the existence of the Laramie Group beneath the surface *debris* all the way, but collected no fossils on that portion of my route. From the valley of the Cache à la Poudre I proceeded eastward to the valley of Crow Creek, another tributary of the South Platte, having its confluence with that river a few miles below that of the Cache à la Poudre. Upon the elevated ground, constituting the watershed between these two tributaries, some five or six miles northeastward from Greeley, I found some slight exposures of strata, among which I recognized the fossiliferous horizon of the neighborhood of Maynard's ranch. Here I obtained not only the *Ostrea* and *Anomia* which I collected there, but also *Corbula subundata* Meek and Hayden, and *Corbicula cleburni* White. Going directly to Crow Creek to camp, I commenced an examination of the valley. I found no exposures of strata between that point and the mouth of the creek, a distance of about five miles, but along the eastern summit of the valley side, where I hoped to have found exposures, the surface was found to be largely occupied by sand dunes. Proceeding up the valley I found no exposures of strata for five miles more, nor until I reached a point about ten miles from the mouth of the creek. From this point to five or six miles farther up the valley I found numerous limited exposures of strata containing many fossils, mainly on the

east side of the valley. In this valley, as in all the plains region round about, the exposures of strata are not only few, but none of them are extensive. The most southerly exposure is about ten miles from the mouth of the creek, and here I again recognized the oyster horizon which has been mentioned twice before. The species mentioned before were found abundantly here, and many other molluscan species besides, in associated layers. I traced this fossiliferous horizon northward for a distance of five or six miles above the point where I first discovered it, and found it to occupy nearly a uniform height above the level of the creek. The exposures are in the face of the low sloping hills that border the east side of the valley, and are distant from the creek only from a few hundred feet to half a mile.

The full section of the strata constituting the valley side here was quite clearly ascertained, although the *débris* which prevails upon the plains has so obscured them in most places, even on the slope, that they were not all observable at any one point. The following is a record of the section as ascertained by measurements at several different points within the few miles that they were found exposed, as before stated:

Crow Creek section.

		Feet.
1.	Sandy soil or *debris* of the plains	10
2.	Grayish siliceous marl	5
3.	Sandy and calcareous layers; with *Corbicula*, &c	3
4.	Soft, sandy, and argillaceous material; with *Ostrea* and *Anomia*	5
5.	Arenaceous rock, somewhat concretionary; with numerous fresh-water forms.	2
6.	Arenaceous marly strata	20
7.	Carbonaceous shale	6
8.	Gray siliceous marl	6
9.	Carbonaceous shale	3
10.	Gray siliceous marl	25
11.	Unexposed to the surface of the creek	5

No. 1 is the prevailing *debris* of the plains, which at top constitutes the sandy soil.

No fossils were found in No. 2, but it is evidently a part of a continuous deposit with those beneath.

No. 3 is remarkably prolific in fossils, especially the genus *Corbicula*, of which there are no less than six or seven distinct species. In this member of the section I also found the majority of the examples of *Melania wyomingensis* Meek, although all its associates are regarded as brackish-water forms. This member of the section is variable, being in some places soft, sandy, and argillaceous, while in others it is mainly composed of harder sandy or argillaceous rock.

No. 4 constitutes one of the most if not the most persistent fossil-horizons in this neighborhood. It is especially characterized by an abundance of the *Ostrea* and *Anomia* which has been before mentioned as characterizing a definite limited horizon in the neighborhood of Maynard's ranch and elsewhere.

No. 5 is a local development of irregular and somewhat concretionary layers, the rock being siliceous, and also somewhat argillaceous and calcareous. The masses in this layer, that are referred to as concretionary, are comparatively large, and are abundantly charged with fossils, while the intervening portions of the layer are less fossiliferous. This member of the section was recognized at only one point, and that at the southern end of the series of exposures in the valley of Crow Creek, now under discussion. Unlike the other fossiliferous layers which compose this section, all of which contain brackish-water forms, No. 5 contains only those which are properly regarded as of purely fresh-water origin,

if we except *Volsella* (*Brachydontes*) *regularis* White, a couple of imperfect examples of which were found among those forms.

No. 6 ought, perhaps, to be properly subdivided, but, being composed of soft material, it was found nowhere freely exposed. Some of the layers seem to have been of purely fresh-water origin, because fragments of a species of *Unio* and one of *Campeloma* were found there; while other layers were as evidently of brackish-water origin, because the *Ostrea* before mentioned was frequently found in them, though it is not so abundant there as in No. 4. Although these fragments of *Unio* were too imperfect for specific identification, they were sufficient for unmistakable generic recognition, and their discovery has especial interest as being the first recognition of that genus that has hitherto been made in the strata of the Laramie Group east of the Rocky Mountains in Colorado, although many species have been discovered in strata of that period west of the mountains and in the Upper Missouri River region.

Nos. 7, 8, 9, and 10 were found exposed only at one locality, in a gully that led down to the creek. Their characteristics are doubtless represented with approximate correctness in the foregoing record of the section, but they were not without some evidence of having been partially disturbed by the valley erosion. Either No. 7 or No. 9, or both, probably represents the bed of coal that is worked at Higley's Mine and elsewhere, and is reported to have been worked in this neighborhood also, but I did not find it. The following is a list of the fossils obtained from the different members of this section:

LIST OF FOSSILS FROM THE VALLEY OF CROW CREEK, COLORADO.

1. *Anomia micronema* Meek.
2. *Anomia gryphorhynchus* Meek.
3. *Ostrea glabra* Meek & Hayden.
4. *Volsella* (*Brachydontes*) *regularis* White.
5. *Anodonta parallela* White.
6. *Unio* ——— ?
7. *Corbicula cleburni* White.
8. *Corbicula obesa* White.
9. *Corbicula cardiniæformis* White.
10. *Corbicula* (*Leptesthes*) *subelliptica* Meek & Hayden.
11. *Corbicula* (*Leptesthes*) *fracta* Meek.
12. *Corbicula* (*Leptesthes*) *macropistha* White.
13. *Corbicula* (*Leptesthes*) *planumbona* Meek.
14. *Corbula subtrigonalis* Meek & Hayden.
15. *Bulinus disjunctus* White.
16. *Bulinus subelongatus* Meek & Hayden.
17. *Physa felix* White.
18. *Goniobasis gracilienta* Meek & Hayden.
19. *Goniobasis nebrascensis* Meek & Hayden.
20. *Melania wyomingensis* Meek.
21. *Viviparus prudentia* White.
22. *Tulotoma thompsoni* White.
23. *Campeloma multistriata* Meek & Hayden.
24. *Corydalites fecundum* Scudder.

NOTES ON THE LARAMIE FOSSILS OBTAINED IN THE VALLEY OF CROW CREEK, COLORADO.

No. 1. *Anomia micronema* Meek.

This species was originally described by Meek in the Bulletin of the United States Geological and Geographical Survey of the Territories,

No. 1, second series, p. 43, "from a shaft sunk on the Kansas Pacific Railroad, 200 miles east of Denver, Colo., 45 feet below the surface, from beds of the age of the Wyoming Bitter Creek coal series." Besides my own collections of this species already recorded, I found it also abundant in the valley of Crow Creek, where it seemed to be confined to No. 4 of the section there. Upper valves only were discovered, almost all of which plainly show the characteristic radiating striæ upon the surface, but upon a few they are obsolete. In view of the apparent identity of the muscular markings and other generic characteristics of *Anomia* possessed by these shells, it seems imperative that we should regard them as bivalves, and yet it is difficult to understand why no trace of an under valve, among the thousands of upper valves that have been collected, has yet been discovered. These remarks apply with equal force to *Anomia gryphorhynchus*, also of the Laramie Group, and so far as I am aware, to all the species of that genus in the American Mesozoic strata. It is worthy of remark that upon some of the shells of the *Ostrea* found in the neighborhood of Maynard's ranch, already mentioned on previous pages, shells of *Anomia micronema* were found adhering after the manner of *Patella* or *Crepidula*. In some cases they were found adhering to both sides of the oyster-shell, always conforming to the inequalities of the surface of the latter, and in all cases with the interior surface of the *Anomia* against the oyster-shell; never the reverse. Furthermore, a careful removal of the adhering shell revealed no trace of an opposite or fellow valve beneath it. These circumstances, together with the fact of the non-discovery of the under valve, as before stated, seem to suggest at least the possibility that only one valve pertained to this mollusk. The existence of the characteristic muscular impressions of *Anomia* in these shells, implying the necessity for both proximal and distal insertion of the muscles into shelly substance, seems, however, to be decidedly against such a supposition.

While the bulk of the shell substance of this species, like that of other species of *Anomia*, is pearly, and often brilliantly so, that portion which is occupied by the nearly centrally located broad muscular scar has a subprismatic structure similar to that of the interlamellar layers upon the outer surface of *Ostrea* or the subepidermal layers of *Unio*, but it is usually less distinctly prismatic than are the portions of the other shells referred to.

The direction of these shell-fibers in the case of the *Anomia* being, as in all other cases, perpendicular to the plane of the valve, and yielding to destructive disintegration more readily than the remainder of the shell, it not unfrequently happens that a hole is thus made through the valve, suggesting that it may be the byssal aperture of an under valve. But in all these cases the muscular markings and other interior characteristics show them to be upper valves, and of course without a byssal aperture.

Anomia micronema, as will be seen from records of species and localities on following pages, is one of the most common species of the Laramie Group on both sides of the Rocky Mountains, having also a great vertical range in that group.

No. 2. *Anomia gryphorhynchus* Meek.

This species was first described by Meek in the Annual Report of the United States Geological Survey of the Territories for 1872, p. 509. His type-specimens were very numerous, and came from a stratum in the Bitter Creek series two miles west of Point of Rocks Station on the Union Pacific Railroad, Wyoming, which stratum holds a position sev-

eral hundred feet beneath the fossiliferous layers at that station, and their equivalents near Black Buttes Station, some twelve miles distant. It has also been found at the higher horizon just mentioned, west of the Rocky Mountains, and a couple of examples were found in the Laramie strata of Crow Creek that seem unmistakably to belong to this species. Besides this, an example, apparently of this species, has been recognized among some fossils collected by Prof. J. W. Powell in the Cañon of Desolation of Green River, Utah. It seems to be a comparatively rare species except at the locality where it was originally discovered.

No. 3. *Ostrea glabra* Meek & Hayden.

The same variations exist among the examples of this species from the valley of Crow Creek, where it is quite abundant, that have been noticed on a previous page as prevailing at the locality in the neighborhood of Maynard's ranch; and the same variations also exist among the examples found here that suggested the reasons before mentioned for regarding *O. wyomingensis* Meek, and perhaps *O. subtrigonalis* Evans & Shumard also, as specifically identical with *O. glabra*. The differences are believed to be mainly the result of difference in age, but they were doubtless due, in part, to environment also.

This species especially characterizes No. 4 of the Crow Creek section, but it is also found sparingly in other members, both above and beneath that one. It is also found in strata both above and beneath the one (No. 5) that appears to have been a purely fresh-water deposit.

A curious habit of this species (not altogether unknown in the case of the living *O. virginica* Gmelin, and first noticed among fossil oysters by Meek, in his description of *O. soleniscus*) is that three specimens not unfrequently attached themselves together by the whole length of their under or deeper valves. Instances of these shells being otherwise attached together are not common, and the great majority of them are entirely free, and show little or no indication of having been attached to anything, at least since they were very small.

The interlamellar layers of prismatic shell structure, commonly observable upon the exterior surface of the shells of living species of edible oysters, have been detected upon all varieties of this fossil species which have been obtained from the Laramie Group. As a rule, however, I have found it more plainly shown upon specimens obtained from localities west of the mountains than east of them; and in the case of all collections I have found it more distinctly shown upon the upper than upon the under valve. The latter peculiarity seems also to prevail in the case of the recent *O. virginica* Gmelin; but in other respects the difference seems to be due to difference in the conditions of their preservation, or rather to the different degrees of their destructive disintegration and not to mere geographical location. It may be mentioned here that I have never been able to detect this prismatic structure upon the shells of any species of the subgenus *Alectryonia*, nor upon any of either *Gryphæa* or *Exogyra*. This does not prove, however, that such a structuer does not exist in those members of the *Ostreidæ*, especially so since I have hitherto failed to find it upon any species of *Ostrea* proper which I have found associated with those forms.

These fossil oysters of the Laramie Group were subject to a pest that produced an effect upon the shells somewhat similar to that which is produced by the burrowing sponge *Cliona* upon the shells of living oysters. This pest to the Laramie *Ostrea* seems not to have been a burrowing sponge, but more probably a burrowing worm. The burrows are very numerous, of uniform size, not larger than a horse-hair, straight or curved,

often branching, the branches being uniform in size with the main burrows. Although these burrows completely "riddle" those portions of the shell where they are most numerous, they are not quite so destructive in their effects as the burrows of *Cliona* are.

A Polyzoan, probably belonging to the genus *Membranipora*, was found encrusting portions of a few shells of this species at Point of Rocks Station, but it has not been observed upon shells from other localities of Laramie strata, except those of Bear River Valley. This Polyzoan will be noticed under the head of collections from both these localities. While the presence of the *Ostrea* and *Anomia* in those strata seems sufficient to prove the saline condition of the water in which they lived, the character of these parasitic or commensal species seems to afford additional proof.

No. 4. *Volsella* (*Brachydontes*) *regularis* White.

The specimens regarded as types of this species, which is described in the Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iv, p. 707, were discovered in beds Nos. 3 and 5 of the Crow Creek section. The species, however, has been recognized at several localities of the Laramie Group west of the Rocky Mountains, as will be noticed on following pages. It was the only presumably brackish-water species that was found in bed No. 5, in which all the other discovered species are regarded as of fresh-water habitat.

No. 5. *Anodonta parallela* While.

This species was discovered in No. 5 of the Crow Creek section, and has not since been recognized elsewhere. It has a peculiar elongate form, resembling *Solemya* in that respect, but its generic characteristics are those of *Anodonta*, and its associated species are all fresh-water forms, except the *Volsella* noticed in the preceding paragraph. It is described in the Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iv, p. 709. With the exception of *A. propatoris* White, discovered by Prof. E. D. Cope in the Judith River beds of the Upper Missouri River, this, so far as I am aware, is the only species of fossil *Anodonta* that has been discovered in any North American strata. The family, however, to which it belongs is well known to be abundantly represented by numerous species of *Unio* in the western portion of the national domain, from the Jurassic beds to the Bridger Tertiary inclusive. The great differentiation of type among even the more ancient of these *Uniones*, and their similarity to living forms, makes it probable that the genus *Anodonta* coexisted with them all. The probable reason why, with the two exceptions named, they have escaped detection, is the well-known fact that their congenial habitat is in still waters and on a soft bottom, and seldom in direct association with any species of *Unio*.

No. 6. *Unio* ——— ?

Only a few fragments of this species were discovered, and these only in No. 6 of the Crow Creek section. They were too imperfect for specific determination, and are interesting only from the fact that they furnish the only evidence yet discovered of the existence of the genus *Unio* during the Laramie period east of the Rocky Mountains in what is now Colorado. The probabilities are, however, that they did exist then and there in considerable numbers.

No. 7. *Corbicula Cleburni* White.

Some five years ago Mr. W. Cleburn discovered this species in the valley of Crow Creek, either at or near the same place where I obtained additional specimens in 1877. This species has hitherto been found only

at that locality, and was obtained only from No. 3 of the section. It is described in the Bulletin of the Geological and Geographical Survey of the Territories, vol. iv, p. 711.

No. 8. *Corbicula obesa* White.

This species has been discovered both in Crow Creek and Bijou Creek valleys, but not elsewhere. It comes from No. 3 of the Crow Creek section. It is described in the Bulletin of the Geological and Geographical Survey of the Territories, vol. iv, p. 712.

No. 9. *Corbicula cardiniæformis* White.

This is a rare but well-marked species. It was found only in bed No. 3 of the Crow Creek section, and is described in the Bulletin of the Geological and Geographical Survey of the Territories, vol. iv, p. 711.

No. 10. *Corbicula* (*Leptesthes*) *subelliptica* Meek & Hayden.

Dr. Hayden originally discovered this species in the valley of Cherry Creek, Dakota, in beds that both he and Meek referred either to the Fort Union or Judith River series, but were unable to decide which. While at the original localities these two groups seem to be sufficiently distinct, subsequent discoveries (most of which are presented in this report) of the fossils of each group associated in the same layers elsewhere make it doubtful whether they will ever be recognized as distinct groups elsewhere than at the original localities. *C.* (*L.*) *subelliptica* is described and figured in vol. ix of the United States Geological Survey; and Mr. Meek there refers to this species as having been found in the valley of Bijou Creek (where I also found it), as well as in the Upper Missouri River region. It comes from bed No. 3 of the Crow Creek section, where it is associated with several other species of that genus.

No. 11. *Corbicula* (*Leptesthes*) *fracta* Meek.

Several imperfect examples and fragments of a species, which is without doubt identical with the one named above, were found in bed No. 3 of the Crow Creek section. The species, which is the type of the subgenus *Leptesthes*, was originally discovered in the upper part of the Bitter Creek series, near Black Buttes Station, Wyoming. It has been found there quite abundantly where it is quite variable in form, and where it also reaches a larger size than the average at the other localities at which it has been discovered. It is known at other localities west of the Rocky Mountains, and was also obtained by Dr. Hayden from the same shaft with Nos. 1 and 13, two hundred miles east of Denver, Colo.

No. 12. *Corbicula* (*Leptesthes*) *macropistha* White.

The type-specimens of this species came from No. 3 of the Crow Creek section, but it was also obtained in the valley of Bijou Creek, and at these two localities only. It is the smallest known species of this subgenus, in which respect it contrasts strongly with the type-species of *Leptesthes*, noticed in the last paragraph. It is described in the Bulletin of the Geological and Geographical Survey of the Territories, vol. iv, p. 713.

No. 13. *Corbicula* (*Leptesthes*) *planumbona* Meek.

This species was obtained in considerable numbers from bed No. 3 of the Crow Creek section, and also, but less plentifully, in the valley of Bijou Creek. It was originally discovered "two hundred miles east of Denver City, on the Kansas Pacific Railroad, where they were found in a shaft at a depth of 40 feet below the surface." By reference to

remarks under the head of No. 1, *Anomia micronema*, it will be seen that that species also was discovered in the same shaft, but at a depth of 45 feet; that is, in a layer beneath the one in which the *Corbicula* here discussed was found. The layers which are respectively characterized by these two species hold the same relative position at both the Crow Creek and Bijou Creek localities. This fact is without important significance, so far as the vertical range of the different species alone is concerned, at least that of the *Anomia*, the vertical range of which is known to embrace almost the entire thickness of the Laramie Group west of the mountains; but it has much significance as indicating great uniformity of the conditions that affected deposition of sediment during the Laramie period in the region which now constitutes a portion of the great plains adjacent to the east base of the Rocky Mountains in Colorado. This subject, however, will be further discussed upon following pages.

No. 14. *Corbula subtrigonalis* Meek & Hayden.

Dr. Hayden obtained the type-specimens of this species from the Judith River Group of the Upper Missouri River region. It is described and figured in vol. ix of the United States Geological Survey of the Territories. Like all species of this genus, it is very variable in surface-markings and outline, but there seems to be no reason to doubt the identity of the specimens found at the Crow Creek locality with the species above named, which is regarded as identical with *C. perundata* of the same authors, and which is associated in the same strata in the Upper Missouri River region. Neither have I any serious doubt of the identity of this species with both *C. tropidophora* Meek and *C. crassitelliformis* Meek, both originally described by him from specimens obtained from the Laramie strata in the valley of Bitter Creek, Wyoming. The latter, according to Meek, was also found associated with No. 11 in the same shaft, 200 miles east of Denver, Colo. The differences between these forms that have received different specific names are believed to be not greater than the range of properly recognized interspecific variation under different conditions of environment. Several of the examples discovered, not only in the valley of Crow Creek, but also in localities west of the Rocky Mountains, are much larger than either of the Upper Missouri River forms, or than any known examples of *C. tropidophora*, but this is believed to be only a variation due to conditions of environment, probably in this case a difference of saltness of the waters.

No. 15. *Bulinus disjunctus* White.*

This species was obtained from No. 5 of the Crow Creek section, and specimens were also obtained from the coal-bearing series of the upper part of the Laramie Group at the Almy coal-mines, near Evanston, Wyo., that appear to belong to this species, but they have the spire somewhat shorter.

No. 16. *Bulinus subelongatus* Meek & Hayden.

This species was originally discovered by Dr. Hayden in the strata of the Judith River Group of the Upper Missouri River, and it was also recognized among some collections made in that region by Professor

---

*This species has not hitherto been described. It closely resembles *B. elongatus* Meek & Hayden, but the spire is more elevated, and consequently the body-volution is proportionally smaller. Besides this, the anterior half of the callus which forms the inner lip is not appressed against and adherent to the body, whereas the posterior half is, and as the whole of it is in other species of *Bulinus*, but it is deflected or disjoined so as to leave a kind of umbilical space between it and the body of the shell. This peculiarity is not accidental, as was at first supposed, but it was observed in all the specimens, young and old, of both the localities at which it was obtained.

Cope in 1876. It is described and figured in vol. ix of the United States Geological Survey of the Territories. Only a few fragments, which I refer to this species, were found at the Crow Creek locality, and only in No. 5 of that section. More perfect examples were found in the coal-bearing series constituting the upper part of the Laramie Group, near Evanston, Wyo., which I refer to this species.

No. 17. *Physa felix* White.

Only two imperfect examples of this species were anywhere discovered, and these only in bed No. 5 of the Crow Creek section. It seems to be a true *Physa*, yet the remarkable inflation of the body volution and a peculiarity of its surface ornamentation suggest probably subgeneric differences. See Bull. U. S. Geol. & Geog. Surv. Terr., Vol. IV, p. 714.

No. 18. *Goniobasis gracilienta* Meek & Hayden.

Dr. Hayden also discovered this species in the Judith River beds; and it is figured and described in vol. ix of the United States Geological Survey of the Territories. A goodly number of examples were found in bed No. 5 of the Crow Creek section, which seem in all respects to possess the typical characteristics of the species. Black Buttes Station, Wyo., is the only other locality at which the species has been recognized, where it is found in strata of the upper portion of the Laramie Group, but all the examples found there are more slender than the types.

No. 19. *Goniobasis nebrascensis* Meek & Hayden.

This species was among the large collections made many years ago by Dr. Hayden, from the Fort Union Group of the Upper Missouri River region. It is described and figured in vol. ix of the United States Geological Survey of the Territories. Both this species and *G. tenuicarinata* of the same author, associated together as they are where they were originally discovered, were obtained by one of the parties under Lieutenant Wheeler's direction at Wales, Utah, and are described and figured in White's Report, vol. ix, Part I, Exploration and Survey West of the One Hundredth Meridian. *G. nebrascensis* was also recognized among some fossils collected by Prof. J. W. Powell from strata exposed in the Cañon of Desolation, of Green River, in Utah; and the same species only was found at the Crow Creek locality, and only in No. 5 of that section. It is possible that *G. tenuicarinata* is only a variety of *G. nebrascensis*, as has been suggested by Mr. Meek; but if so it is an interesting fact that the variation should be so precisely the same at the two very distant localities where the two forms are so intimately associated, while the characteristics that distinguish the last-named form are constant at all the localities where it has been found.

No. 20. *Melania wyomingensis* Meek.

Mr. Meek first discovered some imperfect examples of this fine shell in the strata of the upper part of the Laramie Group, near Black Buttes Station, Wyo., from which he described the species in the Annual Report of the United States Geological Survey of the Territories, for 1872, p. 516. In Professor Powell's Report of the Geology of the Uinta Mountains, published in 1876, on page 131, I unwittingly described the same species under the name of *M. larunda*, from some large and beautifully preserved specimens that were obtained by Mr. W. Cleburn from the valley of Crow Creek some three years previously. Upon my own examination of that region in 1877, I collected a number of specimens of the same species from the same locality. I got fragments of it also from the valley of Bijou Creek; besides which Mr. George L. Taylor, of

Denver, gave me a fine specimen that he informed me came from Horse Tail Creek, a tributary of South Platte River, some seventy-five miles eastward from Greeley, Colo. Besides these specimens from strata east of the mountains, I collected others from the original locality in the Bitter Creek series at Black Buttes Station; at two or three localities in Yampa River Valley; and at one locality in White River Valley. A careful comparison of all these specimens, collected at the localities just named, on both sides of the Rocky Mountains, shows *M. wyomingensis* Meek and *M. larunda* White to be one and the same species. It must therefore take the name originally given it by Meek, which is here adopted.

At the Crow Creek locality it was found in bed No. 5 associated with purely fresh-water forms, but more plentifully in bed No. 3, where it was found associated with *Corbula*, *Corbicula*, &c., but no species were found in that bed that are regarded as purely fresh-water forms. It was found at all the localities named west of the mountains, with similar associates, by which I infer that this species was capable of living in waters that were at least in some degree saline.

No. 21. *Viviparus prudentia* White.

This species has been found only at the Crow Creek locality, and only in bed No. 5 of that section. It is an unusually short species, and in general aspect it recalls the living species, *V. intertexta* Say. It is described in the bulletin of the United States Geological and Geographical Survey of the Territories, vol. iv, p. 716.

No. 22. *Tulotoma thompsoni* White.

No other species of this genus has yet been discovered in American strata, and only one living North American species is known. Its claims to be regarded as a distinct genus from *Viviparus* will be discussed elsewhere. *T. thompsoni* was first discovered by me in the upper strata of the Bitter Creek series of the Laramie Group, at Black Buttes Station, Wyoming, and described in Powell's Report on the Geology of the Uinta Mountains, p. 134. It was then found to occupy a thin layer immediately above one that at the same locality is crowded with *Corbicula*, but the *Tulotoma* apparently had no other than purely fresh-water associates. At the Crow Creek locality it was found only in No. 5 of the section there, its associates being purely fresh-water forms, except *Volsella* (*Brachydontes*) *regularis*, which occurs in that bed as already mentioned, but perhaps accidentally.

It has hitherto been discovered at only these two localities, one on each side of the Rocky Mountains, but this fact shows that it was a widely distributed species, and it is found in large numbers at both localities. The identity of the species at these two distant localities is unmistakable, but there appears to be a greater variation among the examples from the Crow Creek locality than among those obtained at Black Buttes Station, but the latter are mostly very imperfect. One of the variations observable among the examples obtained in the valley of Crow Creek is a tendency of the nodes to become obsolete, even upon the last volution. The aspect of those examples in which the obsolescence of the nodes is greatest is closely like that of the typical forms of *Viviparus trochiformis* Meek & Hayden, thus suggesting the possible passage of a molluscan species from one recognized generic form to another without any clearly definable change of specific characters.*

* Dr. M. Neumayr, of Vienna, has shown a similar gradation to exist between certain Miocene Tertiary forms from Sclavonia which American conchologists would not hesitate to refer respectively to *Viviparus* and *Tulotoma*, but all of which he refers to the former genus. The paleontologist is of course confined to the study of the shell

No. 23. *Campeloma multistriata* Meek & Hayden.

This somewhat variable species was originally discovered by Dr. Hayden in the strata of the Fort Union Group at Fort Clark, Dakota, and is described and figured in vol. ix of the United States Geological Survey of the Territories. It was found in great numbers also by Mr. J. A. Allen over a large area of the Upper Missouri River region, or, more properly speaking, in the region drained by the Yellowstone. Most of his specimens are larger than either the type-specimens or any of those that were found at the Crow Creek locality. They were also distinguished by a greater prominence and angularity of the shoulder at the distal side of the volutions, which, to a greater or less extent, characterizes the species, but no doubt is entertained of their specific identity. The examples found at the Crow Creek locality are closely like the typical examples, and were obtained only from No. 5 of the section there, its associates being fresh-water forms. No unmistakable examples of this species have been discovered at any locality west of the Rocky Mountains, but some imperfect examples of a closely related, if not identical, species were found in strata of the upper portion of the Bitter Creek series at Point of Rocks and Black Buttes stations, in Wyoming. The fragment of *Campeloma* found in bed No. 6 of the Crow Creek section perhaps belongs to this species, but it was too imperfect for specific determination.

No. 24. *Corydalites fecundum* Scudder.

The above name was given by Mr. Scudder, in the Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iv, p. 537, to an insect that laid some remarkable egg-masses, which I discovered associated with a part of the foregoing mollusks in bed No. 5 of the Crow Creek section. No trace of them was found in any other member of the section, nor at any other locality. These egg-masses were found promiscuously intermixed with the shells of branchiferous and pulmonate mollusks, and had evidently been drifted more or less from the place of their original oviposition, as had at least a part of the shells with which they were associated.

Conclusions that in their application pertain alike to all the localities from the strata of which I have made collections of fossils will be reserved for the discussions closing this report, but those observations that were found to be more or less peculiar to separate localities may properly be briefly discussed in more immediate connection with their statement. I may thus especially note here the local and apparently limited development of that member of the Crow Creek section of strata which contains a purely fresh-water fauna. It is true the full extent of that bed is not even approximately actually known, but the locality where it was discovered and examined is apparently its northern border, and no trace of it was discovered at any other locality east of the Rocky Mountains in Colorado. The evidence that its northern border exists at thel ocality mentioned consists in the fact that the bed No. 5 is exposed at only one point, although the whole series of strata which are exposed in

alone, but it is proper to state that Haldeman's genus *Tulotoma* was founded upon the shell only, the soft parts, so far as I am aware, having never been described. The only known living American species of *Tulotoma*, *T. magnifica*, Haldeman's type, is a very variable shell, especially as regards its nodes and carinæ, and it may well be questioned whether any conchologist would have ventured to separate the smoother forms from *Viviparus* if they alone had been known. It is proper to state, however, that the shell of *T. magnifica* is more massive than that of any known living species of *Viviparus*; but, on the other hand, the shell of the fossil species, *T. Thompsoni*, is not thicker than that of *Viviparus* generally is, except where it is thickened by the nodes.

the valley for a distance of five or six miles, and which constitute the Crow Creek section, is frequently cut from top to base by gullies leading directly across the exposures into the creek, and bed No. 5 is nowhere else recognized, although the beds which immediately underlie and overlie it respectively are at those other points clearly distinguishable and in contact. The prevalence of one and the same species of *Ostrea*, both above and beneath the fresh-water bed, also suggests the limited extent of that fresh-water deposit and the unbroken continuity of sedimentary deposition in at least partially saline waters at no great distance away from the limited area in which the fresh-water deposit was made. Although the border of this bed is thus recognized at the Crow Creek locality, it does not seem to possess the characteristics of a true littoral deposit, such as water-worn pebbles, marks of wave action, &c. The presence in it of the insect egg-masses, palustral shells, and fragments of wood and deciduous leaves, however, seem to indicate that a shore-line was not far distant.

A marked peculiarity of the fauna of the Crow Creek locality is the great prevalence of *Corbicula*, including both the typical forms of the genus and those of the subgenus *Leptesthes*. The recognized species are six in all, and some of them appear to be intermediate in character between the typical forms and those of the subgenus *Leptesthes*, and one of them approaches the form to which Mr. Meek has given the subgeneric designation of *Veloritina*.

Other important observations were made in relation to the Laramie Group and its fossils in the valley of Bijou Creek, and elsewhere east of the Rocky Mountains, but the plan adopted for my report is to make the record of my observations in the order of my line of travel. Therefore the Cretaceous rocks of the valley of the Cache à la Poudre and other localities will now be discussed, and the consideration of the Laramie Group and its fossils will be resumed on following pages.

Returning from the valley of Crow Creek to the Cache à la Poudre, I passed up the south side of its valley, by way of Greeley, to a point about five miles westward from the town. Here, and also at intervals within a distance of six or seven miles farther westward, I found the upper series of Cretaceous strata exposed. From these exposures I collected quite a number of species of invertebrate fossils, some of which respectively characterize the different divisions of the Cretaceous series that have been recognized in the Upper Missouri River region, from and including the Fort Pierre Group upward. Those obtained in the valley of the Cache à la Poudre within the limits just named were collected mainly at, and in the vicinity of, the farms of Frank Marcks and Aaron Eaton, respectively.

The dip of the strata in this region is gently to the eastward, but as it is a little greater than the coincident slope of the stream, one comes upon lower and lower strata as he passes westward up the valley. The broad lower lands of the valley are covered with alluvium, and the higher surfaces with the usual prevailing *débris* of the plains, so that the exposures of strata, even in the valley side, are very few, and the thickness exposed at any one locality is very small. Much the most important exposure, as regards extent and thickness of strata, that I observed in this valley, was found at and in the vicinity of Mr. Eaton's farm, where it forms a precipitous bluff near the river, and shows a thickness of strata amounting to about 100 feet. The fossiliferous layers of this exposure are few and limited, but traces, at least, of fossils occur throughout the whole thickness. No continuous measurements of the strata exposed in the valley side within the distance named could be

made, and consequently the aggregate thickness of them is not known. This thickness, however, is estimated to be about 250 feet between Marck's farm and a point about four miles above Eaton's farm.

At the exposures here referred to the following list of fossils was collected, all belonging to the extreme upper portion of the Cretaceous series beneath the Laramie Group. A part of them also characterize the highest known Cretaceous strata beneath the Judith River Group in the Upper Missouri River region, as shown by Meek and Hayden, but the relations of those fossils in this respect will be discussed in connection with those collected at Fossil Creek, Little Thompson Creek, the mouth of the Saint Vrains, &c., because the strata exposed at these localities all belong to one natural group.

LIST OF THE FOSSILS COLLECTED FROM CRETACEOUS STRATA IN THE VALLEY OF THE CACHE À LA POUDRE, FROM FIVE TO TWELVE MILES WEST OF GREELEY, COLORADO.

1. *Fragments of fossil wood.*
2. *Pteria* (*Oxytoma*) *nebrascana* Evans & Shumard.
3. *Nucula cancellata* Meek & Hayden.
4. *Nucula planimarginata* Meek & Hayden.
5. *Tancredia americana* Meek & Hayden.
6. *Veniella humilis* Meek & Hayden.
7. *Cardium speciosum* Meek & Hayden.
8. *Tellina scitula* Meek & Hayden.
9. *Mactra* (*Cymbophora*) *formosa* Meek & Hayden.
10. *Mactra* (*Cymbophora*) *alta* Meek & Hayden.
11. *Dentalium gracile* Hall & Meek.
12. *Cylichna scitula* Meek & Hayden.
13. *Lunatia moreauensis* Meek & Hayden.
14. *Anchura*, ——— ?
15. *Fasciolaria* (*Piestocheilus*) *culbertsoni* Meek & Hayden.
16. *Placenticeras lenticulare* Owen sp.

Leaving the valley of the Cache à la Poudre at a point about four miles west of Aaron Eaton's farm, I went more directly westward toward the mountains. Search was made in this region for the line of junction, or plane of demarkation between these Upper Cretaceous strata and the base of the Laramie Group. In consequence of the great prevalence of the *débris* of the plains, which has already been referred to, I was not successful in this search, although it is quite evident that the lower strata of the Laramie Group occupy the upper part of the slope of the valley side, as well as the higher lands of the region on both sides of the valley. Higley's coal-mine, which has been already mentioned, is opened in Laramie strata in the upper part of the long, low, sloping, opposite valley-side, and its position is thus shown to be not far above these Cretaceous strata, and consequently near the base of the Laramie Group. But this subject will be taken up again on a subsequent page.

Proceeding westward after leaving the valley of the Cache à la Poudre, I found no exposures of rock until I reached Fossil Creek, about two miles east of the base of the foot-hills of the Rocky Mountains. Along a ridge having the local name of "Fossil Ridge," which runs southward from this creek three or four miles parallel with the foot-hills, there are considerable exposures of coarse sandstones containing fossils that characterize the upper series of Cretaceous strata, known in the Upper Missouri River region as the Fox Hills and Fort Pierre Groups. From

Fossil Ridge I passed up to Spring Cañon, and thence through a portion of it among the foot-hills. Some minor hills that lie immediately adjacent to the foot-hills proper are formed of the hardened shales and calcareous layers of the lower portion of the Colorado Group; but the principal foot-hills are mostly in the form of hogbacks that were produced by the upturning of the strata of the Dakota Group and the Red Beds.

I prosecuted a labored but unsuccessful search for fossils in the strata of these hogbacks, as I did, also, in those of Box Elder Cañon, which is a similar gorge, through these same strata, similarly upturned. From their stratigraphical characteristics and relative position the Red Beds were easily recognized as those that have been generally regarded as of Triassic age, and the strata of the Dakota Group were just as readily identified, although no fossils were discovered. There is also a series of strata between these two groups, which, being softer than the others, has yielded more to disintegration. These were recognized and described by the late Mr. Marvine, in his report, as Jurassic strata. In this he was probably correct, but so far as I am aware no invertebrate fossils* of any kind have been found in these strata or in their equivalents east of the Rocky Mountains in Colorado, except a shell found by Mr. Lakes and noticed in connection with fossils found in the vicinity of Golden City, on a following page.

Returning to Fossil Ridge I made considerable collections of fossils there, a part of the species being very abundant. They were obtained mainly from "cannon-ball" concretions, some of which are very large and which were weathered out of softer layers of sandstone. It has already been mentioned that a part of these fossils are of the same species that characterize the Fort Pierre Group of the Upper Missouri River region. It is a well-known fact that several species of fossils are common alike to both the Fort Pierre and Fox Hills Groups, even in the region just mentioned, and this is so especially the case in Colorado that no attempt is made to separate them, and I have in my report of last year ranged the equivalents of both groups under the single name of Fox Hills Group, and shall do so in this report. It is nevertheless true that a greater proportion of the species found in the lower part of the Fox Hills Group, as thus recognized in Colorado, are identical with those of the Fort Pierre Group than with those of the Fox Hills Group, as those two groups are recognized in the Upper Missouri River region. This fact is apparent in the strata exposed in Fossil Ridge, as is shown in the following list of fossils:

Not only this fact, but also the known dip to the eastward, which brings up lower and lower strata toward the foot-hills, indicates that those at Fossil Ridge belong to a lower horizon than those which I examined in the valley of the Cache à la Poudre.

LIST OF CRETACEOUS FOSSILS COLLECTED AT FOSSIL RIDGE, THREE MILES SOUTHEASTWARD FROM SPRING CAÑON, AND ABOUT SIX MILES SOUTH OF FORT COLLINS, COLORADO.

1. *Ostrea patina* Meek & Hayden ?
2. *Pinna lakesi* White.
3. *Pteria linguiformis* Evans & Shumard.

* Some remarkable Dinosaurian remains have been obtained from the upper strata of this group at the town of Morrison, on Bear Creek, Colorado. See address of Prof. O. C. Marsh, Proc. Am. Assoc. Adv. Sci. vol. xxvi, pp. 22 *et seq.* See also further remarks on a following page.

4. *Inoceramus oblongus* Meek.
5. *Inoceramus vanuxemi* Meek & Hayden.
6. *Cardium speciosum* Meek & Hayden.
7. *Callista deweyi* Meek & Hayden.
8. *Mactra (Cymbophora) warrenana* Meek & Hayden.
9. *Glybemeris berthoudi* White.
10. *Anchura haydeni* White.
11. *Baculites ovatus* Say.
12. *Scaphites nodosus* Owen.
13. *Placenticeras placenta* var. De Kay sp.

The different species composing this list will be discussed on following pages, in connection with those of other lists obtained from other localities in this district.

The junction between the Fox Hills strata at or in the vicinity of Fossil Ridge, and the Colorado Group beneath them, was found to be everywhere covered by the *débris* of the plains, but it is probably not more than one or two hundred feet beneath the lowest strata exposed at that locality, as all the strata begin almost immediately to rise rapidly to the foot-hills. I desired very much to know the aggregate thickness of the Fox Hills Group of this region from that junction to the highest strata of the series, at Marcks's farm, but on account of the obscuration of a large part of the series, and the varying dip, I found myself unable to estimate it with any good degree of satisfaction.

Proceeding southward from Fossil Creek to the valley of Thompson River, I examined its valley, without adding materially to the facts already enumerated. I then crossed southeastwardly to the Little Thompson Creek, in the south valley side of which I found some exposures of Cretaceous strata, the aggregate exposed thickness of which is apparently not above 40 or 50 feet. Here I made the collections of the following list, which, it will be seen, corresponds more nearly with those obtained in the valley of the Cache à la Poudre than with the Fossil Ridge collection, a list of which has just been given. It differs somewhat, however, from the collection obtained from the upper layers as they are found both at Marcks's farm, on the Cache à la Poudre, and at the mouth of the Saint Vrains, which latter locality will presently be noticed. I therefore regard these strata in the valley of Little Thompson Creek as holding a position intermediate between the strata of Fossil Ridge and those of the summit of the group as developed in this district.

LIST OF FOSSILS COLLECTED IN THE VALLEY OF LITTLE THOMPSON CREEK.

1. *Crenella elegantula* Meek & Hayden.
2. *Sphæriola ? obliqua* Meek.
3. *Sphæriola ? endotrachys* Meek.
4. *Veniella humilis* Meek & Hayden.
5. *Cardium speciosum* Meek & Hayden.
6. *Protocardia rara* Evans & Shumard sp.
7. *Protocardia subquadrata* Evans & Shumard sp.
8. *Callista deweyi* Meek & Hayden.
9. *Tellina scitula* Meek & Hayden.
10. *Thracia gracilis* Meek & Hayden.
11. *Teredo ?* borings in fossil wood.
12. *Lunatia* ——— ?
13. *Anchura americana* Evans & Shumard sp.
14. *Pseudobuccinum nebrascense* Meek & Hayden.

15. *Placenticeras lenticulare* Owen sp.
16. Fish vertebræ.

From the valley of Little Thompson Creek I continued southeastwardly to the valley of the Saint Vrains, meeting with no other exposures of strata until I reached that valley. Proceeding down the valley upon its northern side I observed a few slight exposures of friable sandstones in the valley side, and although I obtained no fossils from them I regard them as belonging to the Fox Hills Group.

Reaching the confluence of the Saint Vrains with the South Platte River, I found considerable exposures of the uppermost strata of the Fox Hills Group. For the distance of a mile or more, these strata, having a visible thickness of about 60 feet, are exposed in the form of a more or less precipitous bluff with a talus of *débris* at its base. These strata are composed of soft, sandy, and partially argillaceous, bluish, and grayish material below, capped with sandstones above, the layers of which vary in condition from hard and somewhat massive to soft and laminated. The principal or only layer containing invertebrate fossils was found near the top of the section, and only two or three feet in thickness. Some eight or ten feet above this, in softer sandstone layers, that peculiar fucoid, *Halymenites*, was found in abundance. Above this is a few feet of still softer sandy material that merges above into the *débris* of the plains.

As will be seen by the following lists of fossils collected here, these strata are without doubt exactly equivalent with the uppermost layers found in the valley of the Cache à la Poudre, and are doubtless the highest Fox Hills strata that exist in this region; they are also without doubt the highest marine Ceretaceous strata that are yet known in North America.* Between the top of the section at the mouth of the Saint Vrains and the higher adjacent land surface there is sufficient thickness of material to make it evident that the lower strata of the Laramie Group exist there, but they were not recognized with certainty. However, for reasons that I shall state farther on, I think it not improbable that the bed containing the *Halymenites* belongs to the Laramie Group. If so, there is no perceptible plane of demarkation between the Fox Hills and Laramie Groups, at least at this point.

LIST OF FOSSILS COLLECTED AT THE MOUTH OF THE SAINT VRAINS RIVER, COLORADO.

1. *Halymenites major* Lesquereux.
2. *Pteria Haydeni* Hall & Meek.
3. *Nucula planimarginata* Meek & Hayden.
4. *Tancredia americana* Meek & Hayden.
5. *Cardium speciosum* Meek & Hayden.
6. *Protocardia subquadrata* Meek & Hayden.
7. *Tellina scitula* Meek & Hayden.
8. *Tellina equilateralis* Meek & Hayden.
9. *Mactra* (*Cymbophora*) *warrenana* Meek & Hayden.
10. *Mactra* (*Cymbophora*) *alta* Meek & Hayden.
11. *Pholadomya?*
12. *Pachymya herseyi* White.
13. *Dentalium gracile* Hall & Meek.
14. *Cylichna scitula* Meek & Hayden.
15. *Actæon woosteri* White.

*Whether the Laramie Group is of Cretaceous age or not will be briefly discussed on following pages.

16. *Actæonina prosocheila* White.
17. *Lunatia* ——— ?
18. *Fasciolaria* (*Piestocheilus*) *culbertsoni* Meek & Hayden.
19. *Ammonites* ——— ?
20. *Placenticeras lenticulare* Owen sp.
21. *Lamna* ——— ?
22. *Bones and scales of teliost fishes.*

The district which I have thus traversed, and which is embraced between the South Platte River on the east and the base of the Rocky Mountains on the west, and the Cache à la Poudre on the north and the Saint Vrains on the south, probably presents the best exemplification of the Cretaceous groups, more especially of the Fox Hills Group and its fauna, that is to be found east of the Rocky Mountains in Colorado. The strata with which I am now more immediately concerned are those to which I have in my report for last year applied the single name of Fox Hills Group,* and which are here, without doubt, both the stratigraphical and paleontological equivalent of all those in the Upper Missouri River region, to which both the names Fort Pierre Group and Fox Hills Group, Upper and Lower, have been applied. Those northern divisions are no doubt sufficiently characteristic there, but their recognition as indicating seperate epochs of geological time is impracticable here. Therefore, in the following discussion of the species I shall consider as belonging to only one category all that have been separately enumerated as coming from the valley of the Cache à la Poudre, Fossil Ridge, the valley of Little Thompson Creek, and the mouth of the Saint Vrains River; but I shall discuss the subordinate horizons that are indicated by certain of the species, in connection with their separate consideration, in the following notes:

NOTES ON THE FOSSILS OF THE FOX HILLS GROUP AS DEVELOPED IN COLORADO, EAST OF THE ROCKY MOUNTAINS.†

1. *Halymenites major* Lesquereux.

The only localities east of the Rocky Mountains at which I obtained this fucoid is at the mouth of the Saint Vrains, and in the valley of Platte River some eighteen miles east of Greeley, but Dr. Hayden and others report it at several localities in that region, and as holding a similar stratigraphical position. Although I am much inclined to regard this as a Laramie fossil, I discuss it in connection with the Cretaceous fossils of this region as a matter of convenience. Its upward range west of the Rocky Mountains is to the very summit of the Laramie Group, where I have found it near Black Buttes Station, in the valley of Bitter Creek, Wyoming. Even here, however, it was in or beneath strata that contain brackish-water invertebrate fossils. So far as I am aware, it has never been found in stata containing only fresh-water mollusks, but it

* Mr. Clarence King, in his map of the Green River Basin, applied the name Colorado Group to the equivalents of not only the Fort Benton and Niobrara Groups, but he included with them the equivalent of the Fort Pierre Group also, leaving the Fox Hills Group to stand alone, as Hayden and Meek did originally. There are excellent paleontological objections to such a division between the equivalents of Fort Pierre and Fox Hills Groups, but not between those of the Fort Pierre and Niobrara Groups.

† All the invertebrate fossils of this list, unless otherwise stated, are figured in vol. ix of the United States Geological Survey of the Territories. This applies not only to the species originally described by Meek and Hayden, but to those of other authors also.

has been reported from the marine Cretaceous strata of the Fox Hills Group at several points west of the Rocky Mountains. Regarding it provisionally as a Laramie fossil of course implies the reference of the stratum containing it east of the mountains to the Laramie Group, which Dr. Hayden has usually regarded as the lower stratum of the Lignitic series; but as the sedimentation was evidently continuous from the lower to the upper of these groups, he is understood to have selected that stratum as approximately upon the plane of demarcation between them. This fucoid is quite abundant at the Saint Vrains locality.

2. *Fossil wood.*

Fragments of fossilized exogenous wood are somewhat commonly met with in these Cretaceous strata, both in the form of comminuted carbonized material, and that of pieces of wood which, although mineralized, still retain much of the original texture and aspect. In the latter condition it is not unfrequently found to have been bored by a species of *Teredo.*

3. *Ostrea patina* Meek & Hayden?

A few scattered shells of an *Ostrea* were found among the other fossils at Fossil Ridge, which probably belong to this species, which was originally described from the Fort Pierre Group of the Upper Missouri River region. The species of this genus are too variable, and the specimens in question too few to allow of positive specific identification, besides which *O. patina* is an unusually variable species.

4. *Pteria haydeni* Hall & Meek.

Dr. Hayden originally discovered this species in the vicinity of Fort Pierre, on the Upper Missouri River, near the base of the Fort Pierre Group, and with the present exception, so far as I am aware, it has not been found elsewhere. A single valve only was found at the mouth of the Saint Vrains, but it seems to be identical with the species here named. The original description and figure given by Hall and Meek are copied in vol. ix of the United States Geological Survey.

5. *Pteria linguiformis* Evans & Shumard.

This is nowhere a very abundant species, but it is one of the most widely distributed of those which characterize the Cretaceous strata of the West. It occurs on both sides of the Rocky Mountains, but I obtained it myself only at Fossil Ridge, in the district under discussion. It is also known to range through both the Fort Pierre and Fox Hills Groups of the Upper Missouri River region, where it was first discovered. This species is *very* like the *Avicula nitida* of Forbes, from the Cretaceous rocks of Southern India; but it is not my purpose in this connection to discuss questions of identity of these species, except so far as relates to the equivalency of the strata in which I found them with other Cretaceous strata of North America.

6. *Pteria* (*Oxytoma*) *nebrascana* Evans & Shumard.

This is also a widely-distributed and often abundant species, being found in both the Fort Pierre and Fox Hills Groups of the Upper Missouri River region, and also having been discovered far up in British America. It was found abundantly, but not very well preserved, in a thin, soft, sandy, and clayey layer near Frank Marck's farm, five miles west of Greeley.

7. *Pinna lakesi* White.*

This species has been found only at Fossil Ridge, and being new, it has little value for comparison in this discussion.

8. *Inoceramus oblongus* Meek.

This is one of the largest and most robust species of the *Catillus* section of the genus *Inoceramus* that is yet known in American strata. Meek's original specimens were obtained from the vicinity of Fossil Ridge, and, so far as I am aware, it has not been certainly identified in any other district, except the vicinity of Morrison, Colo., where Mr. A. Lakes obtained some imperfect specimens apparently belonging to this species. It is very abundant and generally very large at Fossil Ridge, some of the shells being nearly a foot in length and fully four inches in transverse diameter. The shell substance is comparatively thin, although the shells are so large. Most of the specimens were found with both shells in juxtaposition, as were also those of most of the other associated bivalves, probably indicating that the waters in which they lived and died were comparatively still. It is probable, however, that these *Inocerami* died in the sand into which they had burrowed, and which now forms their stony sepulchre. The original description of this species is in the form of a brief foot-note to page 297 of the Annual Report of the United States Geological Survey of the Territories for 1870. It is also described and figured in another part of this report.

9. *Inoceramus vanuxemi* Meek & Hayden.

Dr. Hayden originally discovered this species at the Great Bend of the Upper Missouri River, and it seems not to be a common species. I found it only at Fossil Ridge, the specimens being apparently identical with authentic examples of the species from the Upper Missouri River region. This species is not improbably the same as *I. sagensis* Owen, but I defer the discussion of that question until a future occasion.

10. *Crenella elegantula* Meek & Hayden.

The original specimens of this species, also, were collected by Dr. Hayden. He obtained them from the valleys of both the North Platte and Yellowstone Rivers, and, so far as I am aware, the species has not been elsewhere found until I obtained it in the valley of Little Thompson Creek, where alone I have found it. Its position there is near the top of the Fox Hills Group as developed east of the Rocky Mountains in Colorado, but in the original localities it was found in both the Fort Pierre and Fox Hills Groups as they are recognized in the Upper Missouri River region.

11. *Nucula cancellata* Meek & Hayden.

This is a widely distributed species, having been collected at various localities in Dakota, Wyoming, Montana, and Idaho Territories. I found some imperfect examples of it in the valley of the Cache à la Poudre, and Capt. E. L. Berthoud has sent examples to the office of the Survey from near Golden City, Colo. At both the latter localities it was found in the upper strata of the Fox Hills Group, but Dr. Hayden found it in the valley of the Yellowstone to range as low as the upper part of the Fort Pierre Group.

---

* This species is named in honor of Mr. Arthur Lakes, of Golden, Colo., and has not hitherto been described. It is sometimes near a foot long, slender, sides not angular along the middle nor very convex; dorsal border longer than the base; posterior border convex, and sloping from about the middle far forward and meeting the base without an angle. Surface marked with slender, slightly-raised, radiating ribs, extending from front to rear and covering both valves above and in part below the median line. The ribs are nearly of uniform size throughout, except near the beak, but are wider apart behind than in front.

12. *Nucula planimarginata* Meek & Hayden.

The localities east of the Rocky Mountains in Colorado at which this species has been found are the valley of the Cache à la Poudre, the mouth of the Saint Vrains, and near Golden City, at all of which places it seems to hold a position near the top of the Fox Hills Group. I am not aware that it has anywhere been found at a lower horizon, it having been found only in the Fox Hills Group of the Upper Missouri River region.

13. *Sphæriola? obliqua* Meek.

The original description of this species is in the Bulletin of the United States Geological and Geographical Survey of the Territories, 2d series, No. 1, p. 46, but it has never yet been figured. I found it only in the valley of the Little Thompson. These and the type specimens are the only representatives of the species yet discovered. The latter were found some eighteen or twenty miles southwestward from the locality of the former.

14. *Sphæriola? endotrachys* Meek.

The type-specimens of this species were obtained from "ninety miles below Fort Benton on the Missouri, from Cretaceous beds holding a position in the very upper part of the Fox Hills Group." I found it in a similar position, associated with the foregoing species, in the valley of Little Thompson Creek. It has never been reported as occurring elsewhere. One of my examples especially shows a still greater degree of roughness of the inner surface than is represented by Meek's figures.

15. *Tancredia americana* Meek & Hayden.

The first known specimens of this species were obtained "from a Cretaceous bed holding a position in the very upper beds of the Fox Hills Group at the mouth of Judith River on the Upper Missouri." I obtained it in the valley of the Cache à la Poudre, and at the mouth of the Saint Vrains, where it holds a similar position. I am not aware that it has ever been found at a lower horizon, and it may therefore be regarded as one of the species which characterize the very highest strata of undisputed Cretaceous age in North America.

18. *Tancredia? cœlionotus* White.

One of the types of this species, which is described and figured in another part of this report, was recognized in a collection sent to the Survey by Mr. J. C. Hersey from "the Cache à la Poudre, ten miles west of Greeley, Colo." Only two examples of it have been discovered, the exact locality of the other not being accurately known.

17. *Veniella humilis* Meek & Hayden.

Dr. Hayden first discovered this species in the Fox Hills Group, on a branch of Cheyenne River, near the Black Hills. I obtained a goodly number of specimens of it, well preserved, in the valleys of the Cache à la Poudre and Little Thompson Creek. At both these localities it seems to hold a position above the middle of the Fox Hills Group, as it is developed east of the Rocky Mountains in Colorado. So far as I am aware, it has never been found west of the Rocky Mountains.

18. *Cardium speciosum* Meek & Hayden.

This seems to be a widely distributed species, and to characterize the uppermost layers of the undisputed Cretaceous rocks of the West, where alone it has been found in the Upper Missouri River region. The lowest horizon at which it is known to have been found is that of the strata at

Fossil Ridge, where I discovered it; which strata, although not separable from the Fox Hills Group in Colorado, are no doubt equivalent with those of the Fort Pierre Group in the Upper Missouri River region. I obtained it in considerable numbers from the higher strata of the Fox Hills Group at the mouth of the Saint Vrains and in the valleys of the Cache à la Poudre and Little Thompson Creek. Some well preserved pieces of the test of this species obtained at Fossil Ridge show that what appear to be nodes between the ribs in certain specimens are in the unchanged shell really holes through its substance. The pieces referred to were found to break along the line of these holes, just as postage-stamps separate along the lines of holes made for that purpose. In other examples from the valley of the Cache à la Poudre I found the appearance of nodes in the place of the holes, just as described by Mr. Meek; but careful examination showed that the supposed nodes consist of the stony filling of the holes in the test, which, being harder, had withstood subsequent weathering better than the test itself. It is possible, however, that the outer end of these holes was covered with a shelly layer; but it must have been only a film at most, for I could discover nothing of the kind in the narrow grooves between the ribs of the specimens referred to, which seemed to be perfectly preserved.

19. *Protocardia subquadrata* Evans & Shumard sp.

Dr. Evans first discovered this species in the Fox Hills Group of the Upper Missouri River region. I obtained it in the valley of the Little Thompson; and I have also recognized it in some collections made by Mr. W. H. Holmes at the mouth of the Saint Vrains. It seems never to have been discovered in the Fort Pierre Group of the Upper Missouri.

20. *Protocardia rara* Evans & Shumard.

Associated with the foregoing in the valley of the Little Thompson, I found some small shells that seem to belong to this species, but their identification was not quite satisfactory.

21. *Callista deweyi* Meek & Hayden.

A few imperfect examples, found both at Fossil Ridge and in the valley of Little Thompson Creek, evidently belong to the *Dosinopsis* section of this genus. They are too imperfect for certain specific determination, but the character of the internal cast and what remains of the shell indicates a proper reference to *C. deweyi.*

22. *Tellina scitula* Meek & Hayden.

This is a very common and widely distributed Cretaceous species, being found on both sides of the Rocky Mountains. It seems, however, to be confined everywhere to the strata of the Fox Hills Group. In this district I obtained it only from the upper strata of that group, and only at the mouth of the Saint Vrains and in the valley of the Cache ā la Poudre.

23. *Tellina equilateralis* Meek & Hayden.

A single valve of a species, apparently the *T. equilateralis* of Meek and Hayden, was found at the mouth of the Saint Vrains. The original examples were found in the uppermost of the Fox Hills layers at the mouth of Judith River on the Upper Missouri. Meek referred the species to *Tellina* from external characters only, and there are reasons for believing that it does not properly belong to that genus.

24. *Mactra (Cymbophora) warrenana* Meek & Hayden.

This species was found in the upper strata of the Fox Hills Group, both at the mouth of the Saint Vrains and near Aaron Eaton's farm in the valley of the Cache à la Poudre; also, at Fossil Ridge, the strata of which are near the base of the group. The examples from both the latter and the first-named localities are referred to this species without hesitation, but those of the second-named locality appear to agree more nearly with the description of *M. (C.) formosa* Meek & Hayden. However, I regard the difference between these two forms as varietal only. The range of the species is through the whole of the Fox Hills Group as developed in Colorado east of the Rocky Mountains, but it seems never to have been found in the Fort Pierre division in the Upper Missouri River region.

25. *Pholadomya?*

A single fragment, evidently belonging to this genus, was found at the mouth of the Saint Vrains. It is plainly different from *P. subventricosa* Meek & Hayden, which has been found only in strata holding a similar stratigraphical position at the mouth of Judith River. It is probably new, but the specimen is too imperfect for characterization.

26. *Glycimeris berthoudi* White.

This fine species has been found only at Fossil Ridge, in strata near the base of the Fox Hills Group. It is figured and described in another part of this volume.

27. *Pachymya? herseyi* White.

This species is figured and described in another part of this volume. It was found by myself only in the upper part of the Fox Hills Group as developed in this district, and only at the mouth of the Saint Vrains and in the valley of the Cache à la Poudre; but Mr. A. Lakes has obtained it from a similarly high horizon in the valley of Bear Creek, near Morrison, Colo. It is figured and described in another part of this volume.

28. *Teredo?*

In a fragment of fossil wood obtained among the other fossils at Little Thompson Creek I detected borings, evidently of *Teredo*, or an allied form, but they were too imperfect for specific determination.

29. *Dentalium gracile* Hall & Meek.

Our examples were found in considerable numbers in the uppermost strata of the Fox Hills Group at the mouth of the Saint Vrains and in the valley of the Cache à la Poudre. They were found only in the form of casts, which, not showing the surface characters very clearly, leave a little doubt whether they may not really belong to another species, but they seem to be identical with *D. gracile*. The type specimens were obtained from the upper beds of the Fort Pierre Group in the Upper Missouri River region.

30. *Cylichna scitula* Meek & Hayden.

The type-specimens of this species were obtained from the Fox Hills Group on the Moreau River, a tributary of the Upper Missouri. It seems not to be a common species, as it has not been reported from any other locality until it was found in the district here discussed. I found it only in the uppermost strata of the Fox Hills Group, and only at the mouth of the Saint Vrains and in the valley of the Cache à la Poudre.

31. *Actæon woosteri* White.

In the district here discussed this species was found only at the mouth of the Saint Vrains. A couple of examples found by Mr. W. H. Holmes on the Rio San Juan, in Southern Colorado, seem to be specifically identical with the Saint Vrains specimens. It is figured and described in another part of this volume.

32. *Actæonina prosocheila* White.

This species has been recognized nowhere except at the mouth of the Saint Vrains, where the type specimens were discovered. It is figured and described in another part of this volume.

33. *Lunatia subcrassa* Meek & Hayden.

In the uppermost strata of the Fox Hills Group, on the Cache à la Poudre, I found a number of specimens which evidently belonged to this species, the type specimens of which were obtained by Dr. Hayden from a similarly high position in the upper Fox Hills strata at the mouth of Judith River. Imperfect examples of a species of *Lunatia* were also found at the Little Thompson Creek and Saint Vrains localities, but they appear to belong to *L. concinna* Hall & Meek.

34. *Anchura haydeni* White.

This remarkably large and fine species has been found only at Fossil Ridge, and in strata that belong near the base of the Fox Hills Group, as it is developed and recognized east of the Rocky Mountains in Colorado. It is figured and described in another part of this volume. A calcareous substance was found almost entirely encrusting the spire of the typical example, which is apparently that of a *Nullipora*. At first I supposed it to be an encrusting callus formed by the mollusk itself, such as that of *Calyptraphorus* Conrad and *Lispodesthes* White; but careful examination shows it to be parasitic, or at least not connected with the shell.

35. *Anchura americana* Evans & Shumard.

The types of this species were obtained from beds in the Upper Missouri River region, in which were found a mixture of the characteristic fossils of the Fox Hills and Fort Pierre Groups respectively. In the region here discussed I found the species only at the Little Thompson Creek locality. Some fragments, apparently belonging to this species, were found in the valley of the Cache à la Poudre, but they were too imperfect for satisfactory determination.

36. *Pseudobuccinum nebrascense* Meek & Hayden.

This species, originally discovered in the strata of the Fox Hills Group of the Upper Missouri River region, was found holding a similar position in the valley of Little Thompson Creek. It seems to be a rare species.

37. *Fasciolaria* (*Piestocheilus*) *culbertsoni* Meek & Hayden.

Imperfect specimens of a species of this genus were found at the mouth of the Saint Vrains, and also in the valley of the Cache à la Poudre. I have referred them to *F.* (*P.*) *culbertsoni*, but their specific identification is not quite satisfactory, partly inconsequence of the imperfection of the specimens and partly owing to the difficulty I have encountered in recognizing, in the specimens I have examined, the specific differences relied upon by the authors quoted in separating their published species.

38. *Baculites ovatus* Say.

This widely distributed species was found at Fossil Ridge, but it has not been discovered in the upper strata of the Fox Hills Group in the

region under discussion, nor has it been found in the upper Fox Hills strata of the Upper Missouri River region. Its first appearance in the Cretaceous rocks of the West seems to be at the base of the Fort Pierre Group, in the last-named region, and it apparently became extinct there before the close of the Fox Hills period. In the uppermost strata of the Fox Hills Group of that region it seems to be replaced by *B. asper* Morton, or an allied species, but, as will be seen on a subsequent page, I found it associated with *Cardium speciosum* and *Mactra alta* in the upper strata of the Fox Hills Group in the valley of White River, west of the Rocky Mountains.

39. *Scaphites nodosus* Owen.

Some good examples of this species were obtained at Fossil Ridge, but it was found at no other locality in this district. In the Upper Missouri River region it seems to be confined to the Fort Pierre Group, and it also seems to hold a similarly low position here.

40. *Ammonites* ———.

A fragment of an *Ammonites* was found at the Little Thompson Creek locality, which appears to differ from any described species, but it is too imperfect to base a satisfactory description upon.

41. *Placenticeras lenticulare* Owen.

This species was found in at least a recognizable condition at Fossil Ridge, at the mouth of the Saint Vrains, and in the valleys of the Cache à la Poudre and Little Thompson Creek. It seems to range through the whole Fox Hills Group, including the Fort Pierre division.

42. *Fish remains.*

The only vertebrate remains discovered in the Cretaceous strata of this district were those of fishes, and which are very rare. At the mouth of the Saint Vrains I found a single imperfect tooth; and in the same strata a few vertebræ and fragments of other bone and a few scales of teliost fishes were discovered. Two or three similar vertebræ were also found in the valley of Little Thompson Creek.

The object of the foregoing lists of fossils and accompanying notes is the presentation of ready means for the comparison of the fauna of those Cretaceous strata of Eastern Colorado which I especially examined in the season of 1877, with that of the equivalent strata of the Upper Missouri River region, the grouping of which by Hayden and Meek has become typical in the paleontological history of the West. In the course of my field investigations east of the Rocky Mountains in Colorado I also examined the Cretaceous strata of the Colorado and Dakota Groups; but as I only obtained a few fossils from them, and these being all quite different from any of those of the Fox Hills Group already enumerated in the foregoing lists, I defer a consideration of them to a subsequent page. Besides those Fox Hills fossils already enumerated, I also obtained others from near the towns of Golden and Morrison, Colo., but as they present no additional facts of general application in the following discussion, I shall consider them separately on a subsequent page, in relation to other facts of important but more restricted application.

For the purpose of avoiding confusion in the minds of those who shall read this report, it may be well to repeat the statement already made in a foot-note, that the original grouping of the Cretaceous strata adopted by Hayden and Meek for the Upper Missouri River region, which is still regarded as entirely appropriate there, has been so modified for Colorado and the Territories adjacent as to include the equivalent strata of both

the Fort Benton Group (Cretaceous No. 2) and the Niobrara Group (Cretaceous No. 3) in a single group, under the name of Colorado Group. Also the consolidation of the Fort Pierre Group (Cretaceous No. 4) and the Fox Hills Group (Cretaceous No. 5) under the single name of Fox Hills Group. It is in this sense that the latter name will be used in all references to the Cretaceous strata of Colorado and adjacent Territories; but for the Upper Missouri River region it will continue to be used in the restricted sense applied to it by its authors. This consolidation will reduce the Cretaceous groups as recognized in Colorado and Territories adjacent to three, the names of which are, in the ascending order, Dakota, Colorado, and Fox Hills Groups.

The Dakota Group (Cretaceous No. 1) is so constant in its lithological and paleontological characteristics over the great Western region as to separate it distinctly from all the others. No species of any kind, so far as I am aware, has been found to pass up from it into the Fort Benton Group or equivalent strata. In Colorado and Territories adjacent, neither the lithological nor paleontological characteristics of the equivalents of the Fort Pierre and Fox Hills Groups, respectively, are such as to afford any satisfactory ground for a separation, such as has been made in the Upper Missouri River region; and even in that region a blending of the fossils of each has been frequently found. Precisely similar remarks may be made concerning the equivalents of the Niobrara and Fort Benton Groups. Between the equivalents of these two groups on the one hand and those of the Fort Pierre and Fox Hills Groups on the other there is, however, a well-marked paleontological difference; in some places with a corresponding lithological change, but in other places with no change of the latter character to separate the two consolidated groups. It is to this fact that are largely due the discrepancies between the surface limits assigned by different geologists to the Fox Hills and Colorado Groups respectively in Colorado and Territories adjacent, some of whom appear to have given little attention to the paleontological characteristics of the strata they examined or ignored their importance in the grouping of strata. With this statement and definition of terms, I return to the consideration of the fossils of the foregoing lists.

Of the forty-two species or entries embraced in the foregoing notes, fifteen are either at present unknown in Upper Missouri strata, or they are otherwise irrelevant in the comparison here proposed, between the fossils obtained from the consolidated Fox Hills Group east of the Rocky Mountains in Colorado, and those of the Fort Pierre and Fox Hills Groups together, of the Upper Missouri River region. Twenty-six species of that list were first described from either one or the other or both of those groups in that region. In that northern region eight of these species are common to both the Fox Hills and Fort Pierre Groups; five are confined, so far as known, to the Fort Pierre Group, eight to the Fox Hills Group, and five of them, not including any of the others, are there known only in the uppermost strata of the Fox Hills Group, a series which Mr. Meek was at one time disposed to separate as a subdivision of the Fox Hills Group proper, if not to make it a group coördinate with the others.

The strata of Fossil Ridge are among the lowest of the series in question that found in Colorado east of the mountains, and they are no doubt equivalent with the Fort Pierre Group of the Upper Missouri, and yet they are plainly not separable from the Fox Hills Group in Colorado. The following is a statement of the relations of its list of thirteen species of fossils, as given on a previous page, with those of the

Fox Hills and Fort Pierre Groups in the Upper Missouri River region. Four species are new and therefore irrelevant; five are common to both the Fort Pierre and Fox Hills Groups; one (*Cardium speciosum*) is known only in the uppermost strata of the Fox Hills Group in that region, and, so far as known, only three are there confined to the Fort Pierre Group alone.

Of those thirteen species found at Fossil Ridge, only four were discovered by myself in any of the higher Fox Hills strata of that district. This fact shows a very considerable difference between the fauna of the lower and that of the upper portions of the Fox Hills Group as it is developed in Eastern Colorado; but the other facts cited show that the difference is not sufficient to warrant its separation into two distinct groups, as has been done in the Upper Missouri River region. Furthermore, while certain species seem to be confined to the uppermost strata, both in Colorado and the Upper Missouri River region, these strata are so intimately connected with those beneath them, by other fossils, that range from one to the other, as to make any proper separation of them from the Fox Hills Group proper impracticable. In short while the limitation of the vertical range of certain species serves as an approximate indication of recognizable horizons within the vertical limits of the Fox Hills Group as developed in Eastern Colorado, the range of other species is such as to connect the whole together into one natural group only.

Leaving the district between the South Platte and the base of the Rocky Mountains, which I found occupied by the strata of the Fox Hills Group, I crossed that river at Evans and passed down the south side of its valley to the mouth of Bijou Creek, one of its tributaries from the southward. At a point about eighteen miles east of Greeley I found the uppermost strata of the Fox Hills Group in the south valley side of South Platte River, and from that point to about six miles farther eastward I continued to see small exposures of the same, most of which were obscure. I however recognized about 20 feet in thickness of strata, and the fossils, which were few and imperfect, were quite sufficient to indicate an exact equivalency of the strata containing them with those of the upper part of the section at the mouth of the Saint Vrains. Besides these few characteristic invertebrate fossils, I also found fragments of the fucoid *Halymenites major* in one of the upper layers. The known general dip of the strata of all that region makes it practically certain that the Cretaceous strata pass beneath the level of the streams along a northward and southward line, which may be drawn a couple of miles west of Greeley; that they receive a greater or less thickness of Laramie strata upon them beneath the *débris* of the plains. Then a gentle rise brings them up again to view in the valley of South Platte River, from eighteen to twenty-five miles east of Greeley, as already mentioned. They seem then to pass again by a gentle easterly dip beneath the surface of the river, but I did not trace them farther, as my journey led up the valley of Bijou Creek. It is probable, however, that the exposures of these uppermost of the Fox Hills strata continue at the surface farther down the South Platte, in its immediate valley. Between Greeley and the point where these Cretaceous strata are exposed, the space is no doubt occupied by at least a small portion of the strata of the Laramie Group, which are covered with the *débris* of the plains, but I found no exposures of Laramie strata until I reached the valley of Bijou Creek, about twelve miles above its mouth. In the higher portions of the valley side of South Platte River, where I hoped in passing to have discovered exposures of Laramie strata, I found many sand dunes or accumulations of apparently wind-drifted sand, such as those that have been already mentioned as

existing upon the east valley side of Crow Creek, four or five miles above its mouth. I discovered similar dunes only in the neighborhood of South Platte River.

The valley of Bijou Creek is merely a broad, shallow depression in the surface of the plains, bordered by ill-defined valley sides from two to five miles apart, the elevation of which is, perhaps, 50 feet above the level of the creek. The lower ten or twelve miles of the valley is apparently without any exposures of strata, but the district which it traverses is, doubtless, underlaid by a greater or less thickness of the Laramie Group, beneath the abundant *débris* of the plains. This opinion is based upon the known easterly general dip of all the strata of the region, the known existence of the uppermost layers of the Fox Hills Group in the valley of the South Platte, ten or twelve miles west of the mouth of the creek, and the existence of Laramie strata, presently to be described, in the west valley-side of the creek. These exposures of Laramie strata first appear opposite, and about four miles west of, the junction of Muddy Creek with the Bijou, and continue southward, at intervals, some three or four miles up the creek. The exposures are small and inconspicuous, but I made out satisfactorily the following section in the slope of the low hill or valley-side:

Bijou Creek section.

	Feet.
1. Sandy soil and *débris* of the plains	20
2. Ordinary light-brown sandstone	5
3. Sandy shales	5
4. Shale, sandy and argillaceous, containing *Corbicula*, &c	4
5. Similar to No. 4, containing *Ostrea* and *Anomia*	3
6. Unexposed to the general low surface of the valley, about	15

Although in full detail the recognized members of this section differ, as we should expect them to do, from those of the Crow Creek section, some 35 miles distant, yet no hesitation is felt in recognizing the precise general equivalency of the two sections. This recognition is all the more satisfactory because two or three of the members of each section, respectively, are unmistakably identical, as will be seen from the following comparison:

No. 1 of the Bijou Creek section doubtless corresponds with Nos. 1 and 2 of the Crow Creek section; No. 4 of the former with No. 3 of the latter; and No. 5 of the former with No. 4 of the latter. Nos. 2 and 3 of the Bijou Creek section are not definitely recognized in that of Crow Creek, but this is of no consequence in view of the precise agreement of the fossiliferous members of the section, which are of far more importance than the others. The material composing No. 1 of the Bijou Creek section is too uniform in all this region to need comparison or special description. The sandstone of No. 2 differs in no respect from the ordinary sandstones of the Laramie Group that are found elsewhere. No fossils were found in it. No. 3 is not separable lithologically from No. 4, beneath it, and they are treated as separate members only because I found no fossils in No. 3, while No. 4 is quite fossiliferous, containing at least six species that are identical with those of No. 3 of the Crow Creek section. No. 5 contains *Ostrea glabra* Meek & Hayden and *Anomia micronema* Meek in abundance, and in all respects like those of the Crow Creek section; and, so far as I could discover, no other species were associated with them. No trace of an equivalent of No. 5 of the Crow Creek section, was found at the Bijou Creek locality. It is a fresh-water deposit, and its local character in the valley of Crow Creek has already been remarked upon.

No strata were seen *in situ* in No. 6 of the Bijou Creek section, but at

numerous points on the slope of the valley-side, and not more than four or five feet beneath the base of No. 5, the prairie dogs had, in their burrowing, brought to the surface fragments of coal and carbonaceous shale. This indicates the existence of a bed of coal there, which, if identical with that of the Crow Creek locality, implies an absence in the valley of Bijou Creek of an equivalent of a considerable part of the Crow Creek section beneath its No. 5. But it is more probable that the coal of Bijou Creek is a local development of another bed, which is not represented in Crow Creek Valley where the section was measured, and also that the upper and more fossiliferous part only of the Crow Creek section is represented in that of Bijou Creek.

LIST OF FOSSILS FROM THE VALLEY OF BIJOU CREEK, COLORADO.

1. *Anomia micronema* Meek.
2. *Ostrea glabra* Meek & Hayden.
3. *Corbicula obesa* White.
4. *Corbicula (Leptesthes) subelliptica* Meek & Hayden.
5. *Corbicula (Leptesthes) macropistha* White.
6. *Corbicula (Leptesthes) planumbona* Meek.
7. *Corbula subtrigonalis* Meek & Hayden.
8. *Melania wyomingensis* Meek.

NOTES ON THE LARAMIE FOSSILS COLLECTED IN THE VALLEY OF BIJOU CREEK, COLORADO.

All the species of this list were also found in Crow Creek Valley, and they are separately discussed in notes on the fossils of that locality, on preceding pages. Therefore the notes on this list of fossils will be very brief, and the reader is referred to the notes on the same species of the Crow Creek list.

The examples of *Anomia micronema* and *Ostrea glabra* were found quite abundantly at the Bijou Creek locality, but only in bed No. 5; and no other species were found immediately associated with them. This association of the two species and exclusion of others, in a single stratum, has also been recognized at other localities east of the mountains.

The four species of *Corbicula* named in the list were found associated in bed No. 4 of the Bijou Creek section and in none of the others. Fragments of *Corbula subtrigonalis* and *Melania wyomingensis* were also found associated with them, and all six of these species were found similarly associated in bed No. 3 of the Crow Creek section. The condition of the fossils at the two localities respectively is practically the same, but I observed that the beaks and umbonal portions of some of the specimens of *Corbicula obesa* were eroded, having apparently been done during the life of the mollusk, as the material of the imbedding matrix filled the eroded cavities. This condition was observed in the case of no other species, nor was it observed upon the same species at the Crow Creek locality, the only other place at which the species is known to occur.

The whole valley of Bijou Creek, from its mouth to the crossing of the Kansas Pacific Railroad, was searched for other exposures, but no others were discovered except a few at and in the neighborhood of Bijou Station, where that railroad crosses the creek. These consisted of soft ferruginous sandstone with bluish and variegated shaly and clayey alternating layers. They appear to belong in the series just above the section further down the creek that has already been recorded, or they are perhaps in part identical with No. 2 of that section.

From the valley of Bijou Creek my investigation led me southwestward to Cherry Creek Plateau, during which I passed over the higher strata of the Laramie Group, which come in the series between those that I found exposed near Bijou Station and the sandstones of the Monument Creek Group, that constitute the plateau. I found no fossils of any kind in these higher Laramie strata except silicified wood, which in some places was quite plentiful. It is possible that certain layers in this portion of the Laramie Group contain invertebrate fossils, but the whole series in this region above the horizon of the fossiliferous layers of the Crow Creek and Bijou Creek sections is apparently destitute of invertebrate remains.

The whole thickness of Laramie strata which I thus passed over, from the uppermost layers of the Fox Hills Group in the valley of South Platte River to the base of the Monument Creek Group on Cherry Creek Plateau, is estimated at about 1,800 feet. So far as I could discover, only about the lower 200 or 250 feet of this series is known to contain invertebrate fossils; and the lower 700 or 800 feet appears also to contain all the coal of the Laramie Group in this region.

Exhibiting to some ranchmen whom I met in the valley of Bijou Creek the fossils I had collected there, they informed me that they had found similar ones some twenty-five or thirty miles directly to the eastward; and, as already stated, *Melania wyomingensis* is similarly reported to occur on Horse Tail Creek, upon the south side of the South Platte, and about seventy-five miles eastward from Greeley. These reports are not offered as conclusive evidence of the existence of Laramie strata at those two localities, but taken in connection with other known facts, we are at least warranted in accepting them as provisional evidence. The other facts referred to are the known easterly dip of all the strata near the mountains and their almost level extension out upon the plains; and the known presence of characteristic Laramie strata on the line of the Kansas Pacific Railroad, two hundred miles east of Denver, as already recorded on previous pages. In short there seems to be no reason to doubt that immediately beneath the *debris* of the plains, the strata of the Laramie Group occupy, besides other considerable areas to the northward and southward, the whole broad space between the South Platte and Arkansas Rivers (except narrow spaces immediately adjacent to the two rivers respectively, where the strata of the Fox Hills Group appear to come up to the surface), extending eastward from the base of the Rocky Mountains quite within the limits of Western Kansas.

Sedimentation seems where I crossed the place of division to have been continued without interruption from the Laramie Group, which is mainly a brackish-water, but in part a fresh-water deposit, to the Monument Creek Group, which is probably a purely fresh-water deposit, although no invertebrate fossils have been found in it. This last-named deposit is probably equivalent with the White River Tertiary, a formation that has already been mentioned as occupying a large area of the plains north of the South Platte, but from my present limited personal knowledge I regard it as possibly equivalent with either the Wasatch, Green River, or Bridger Group, which have their full development west of the mountains. It is possible that the upper 800 feet of what I have referred to the Laramie Group ought also to be included with the Monument Creek sandstones, but as I discovered no plane of demarkation between the groups where I examined them I prefer to leave it with the Laramie Group.

Following these statements it is proper that I should make some reference to the reported discovery of marine Tertiary fossils by Professor Powell in the valley of Bijou Creek, as reported upon by myself in

his Report on the Geology of the Uinta Mountains, and also noticed in the American Journal of Science, vol. xi, 3d series, p. 161.

The Bijou Creek locality, the strata and fossils of which have been described on previous pages, is the same one at which the marine fossils just referred to were reported to have been obtained by Professor Powell, and I visited it with specific information furnished by him.* That collection of Professor Powell's was composed entirely of marine species, among which was a coral, and they were referred by me to the age of the Eocene Tertiary strata at Vicksburg, Miss. The fossils which I found at the Bijou Creek locality were not only all of different species, but they were all of either brackish- or fresh-water origin, and identical with species especially characteristic of the Laramie Group. The serial continuity of the strata seems so perfect, from the uppermost strata of the Fox Hills Group as seen in the valley of the South Platte and its branches, to those of the Monument Creek Group upon Cherry Creek Plateau, that it is in the highest degree improbable that a marine deposit could have been made in this region between the close of the Fox Hills epoch and the beginning or even the close of the Monument Creek epoch. If such a deposit were made there at the close of the latter epoch we ought to find it, if found at all, resting on the uppermost strata of the last-named epoch, but none has been reported to exist there. If made at the beginning of the Monument Creek epoch the conformity of its strata upon those of the Laramie Group could not be either real or apparent as it is now. From the explanation that has already been given of the character and condition of the strata between the South Platte and Arkansas Rivers it is evident that if a marine deposit later than the Cretaceous really exists there it must rest unconformably upon the eroded surface of Laramie strata. The great erosion that has left the strata of that region in their present condition took place after the close of the Monument Creek epoch, and that would bring the date of such an assumed marine deposit later than that which is indicated by the character of the fossils of Professor Powell's collection. From these facts and considerations I am forced to the conclusion that the marine Tertiary fossils referred to were collected in some more eastern region and that they were inadvertently substituted in the collections furnished me by Professor Powell for investigation for fossils that he did collect in the valley of Bijou Creek.

Scarcely any subject connected with the geological history of North America could be of more absorbing interest than that of the exact chronological relation of the marine Tertiary deposits of the sea-border regions with the fresh- and brackish-water deposits of the western interior of the continent. It is to be hoped that this subject may yet receive elucidation from discoveries similar to that which was supposed to have been made in the valley of Bijou Creek; but it now seems evident that we need not look for them east of the Rocky Mountains in any district west of Western Kansas. This subject is further referred to in discussions upon later pages of this report.

From the Cherry Creek Plateau I went to the neighborhood of Golden City by way of Denver without adding any material geological or paleontological facts to those already recorded. In my investigation of this district I was accompanied by Mr. Arthur Lakes, of Golden City, and our first examinations were made at the village of Morrison, seven miles to the south of Golden. The strata here are exposed on a grand scale,

---

* In Professor Powell's report on the geology of the Uinta Mountains the name of the locality is given as "Bijou Basin," which was intended to mean the valley of the Bijou Creek, and not a locality near the head of the creek to which that name is given on some maps.

both in the form of the hogbacks that skirt the base of the Rocky Mountains and form its foot-hills, and as natural sections in the valley sides of Bear Creek which cuts transversely through them on its way from the mountains to the plains. These rocks are very clearly illustrated in a section facing page 32 of Dr. Hayden's Annual Report for 1874.

At the time of my visit, Mr. Lakes and Professor Mudge were engaged in exhuming some enormous Dinosaurian remains from the western or escarpment face of the principal hogback, a couple of miles north of Morrison. These strata form the member of the section referred to, which is there designated as "variegated shales," and which immediately underlies the layers of massive sandstone that form the crest of the principal hogback. These sandstone layers are referred without hesitation to the Dakota Group or Cretaceous No. 1, in which reference all other geologists who have mentioned them are understood to agree.

Upon the discovery of the Dinosaurian remains above referred to, Professor Marsh referred the strata containing them to the age of the Wealden of Europe;* but in the final publication of his address before the Am. Asso. Adv. Sci. for 1877, he referred them to the Jurassic. In his later conclusion I am much inclined to agree, not that invertebrate paleontology furnishes any direct evidence, but because of the evidence that exists of unbroken continuity of deposition from those strata that are regarded as certainly of Jurassic age with those containing the Dinosaurian remains, called "Atlantosaurian beds," by Professor Marsh.†

Only a few fossils were collected in this vicinity at the time of my visit; but Mr. Lakes subsequently sent to the office of the Survey a box of fossils which he collected here, containing many species, a list of which is given in an appendix to this report, and they are also included in a list of the fossils of this district, presently to be given, together with notes upon them.

The fossils of this locality were collected mostly from the strata of the Fox Hills Group; but three species, namely, *Inoceramus deformis*, *I. problematicus*, and *Ostrea congesta*, are from those of the Colorado Group. These three species were in fact found in some layers of limestone or calcareous rock at the upper part of the Colorado Group, which no doubt in part represent the Niobrara division of the Cretaceous section of the Upper Missouri River region.

Search for fossils was prosecuted in the strata of the Table Mountains of this district, which are mainly composed of strata of the Laramie Group, and are capped by a trap outflow. In this search I was not successful, although the strata are no doubt equivalent with those that were found so fossiliferous in the valleys of Crow and Bijou Creeks. Continuing my examination of the Cretaceous strata northward, I visited the valley of Ralston‡ Creek, about four miles northward from Golden City. At a locality in the valley of this creek, near the foot-hills and about four miles northward from Golden City, a shaft was sunk several years ago in a search for coal. A bed of lignite was found there which, although not proving profitable for working, is reported to possess about

* See Introduction and Succession of Vertebrate Life in America, page 17; advance copy of Professor Marsh's Address before Am. Assoc. Adv. Sci. 1877.

† Dr. Hayden referred the exact equivalent of these beds on the Saint Vrains and Big Thompson Creeks to the Jurassic in his annual report for 1873. (See sections facing page 20 of this report.)

‡ There seems to be some confusion as to the name of this creek. In the various reports referring to fossils there it is called "Ralston Creek;" but on the maps of the atlas of Colorado it is called "Van Bibber Creek." It is the first creek north of the North Table Mountain, while on the map the name Ralston Creek is applied to the second one north of that mountain.

the same general characteristics as that which is mined in the face of Table Mountain, near Golden City, three or four miles away.

Mr. W. H. Holmes, artist and geologist of the Survey, visited the place about that time and collected a few specimens of a shell that Mr. Meek afterward described as *Cyrena? holmesi* in the Bull. U. S. Geol. Surv. Terr. 2d ser. No. 1, p. 45.

The shells were found in the uppermost of the layers that were dug through in sinking the shaft, and, so far as I can learn, no other fossils were found in any of the other layers. I was not able to learn at what depth the coal was found beneath these fossiliferous layers, but it was probably not more than fifty feet. The strata, as I saw them by looking down the shaft, were alternating layers of soft and harder sandstone with sandy shales, and the series of layers appeared, and are reported to have been found without any material change from top to the coal below. The *débris* and soil so completely cover the valley sides and its neighborhood as to obscure all strata adjacent to those that were seen in the shaft, and the surface presents no direct indication that the strata beneath have ever been violently disturbed. Mr. Holmes, therefore, not being in possession of the paleontological facts which I have since ascertained, supposed the natural position of the fossils referred to, to be above the bed of coal which is mined in Table Mountain, near Golden City, as it was found now to be above the coal in the shaft.*

A year or two after Mr. Holmes's examination of this district Mr. Arthur Lakes also examined the strata of the then abandoned shaft, and besides specimens of *Cyrena? holmesi* he found associated in the same layer an unmistakable fragment of a *Scaphites*. According to our present knowledge of the geological range of this genus, this discovery is assumed to show conclusively the Cretaceous age of the strata in question. This specimen is too imperfect for full specific identification, but it seems to belong to *S. mandanensis* Morton, which indicates the epoch of the Fox Hills Group. As there seemed to be no stratigraphical break between the layers containing the fossils and those in contact with the coal, the latter has been inferred to be of Cretaceous age also; but the following difficulties are in the way of such a conclusion:

Nothwithstanding the fact that west of the Rocky Mountains coal has been found in both the Fox Hills and Colorado groups, so far as I am aware no indication whatever of coal has yet been found in the strata of either of those groups, nor in any strata older than those of the Laramie Group, east of the Rocky Mountains in Colorado. All the Mesozoic strata known in this region are well exposed in this immediate neighborhood, and they have been carefully explored for coal without success. Again, some small masses of compact calcareous rock were obtained from Mr. Geo. L. Taylor of Denver, Colo., labeled, "From near Colorado Springs, Col." These were filled with shells almost certainly identical with the *Cyrena? holmesi* of Meek, and imbedded among them I found a fragment of a gasteropod having the characteristics of *Lunatia* so far as they could be ascertained. This is the history of the perplexing discovery at Ralston Creek at the time of my visit there in 1877.

Being in possession of the foregoing paleontological facts I could not accept the reference to Laramie or later age of the strata containing *Cyrena? holmesi*, and I made as careful an examination as possible of that neighborhood with a view to a proper understanding of the true condition of the strata there, and with the following result:

* So far as I am aware, Mr. Holmes never published his observations in this district, and the view he then held is inferred from the statement made by Mr. Meek in connection with his description of *Cyrena? holmesi* (*loc. cit.*).

As is shown in the numerous sections which accompany Dr. Hayden's reports upon this region, all the Mesozoic strata are upturned against the flanks of the Rocky Mountains; the whole series, including the Laramie Group, thence extending out almost horizontally upon the plains.

The Laramie strata were originally flexed with the others, but being softer they have mostly, but not in all cases, been removed by denudation from the immediate line of flexure, so that we oftener than otherwise see these strata in a nearly level position, while the others close by are flexed. But they are plainly seen to rest upon the strata of the Fox Hills Group, and no distinct stratigraphical plane of demarkation has yet been detected between them.

The outflow of the trap which now caps the two Table Mountains in the immediate vicinity of Golden City, the northern side of the northern one of which is near to the locality under discussion, took place at a comparatively late date, and its outburst must have necessarily ruptured and, at least locally, disturbed the strata at and around the place of exit. The little group of hills immediately upon the north side of Ralston Creek, and at the southern base of one of which is the coal-shaft with its fossiliferous layer of sandy shale, here considered, are composed entirely of trap similar to that which caps the adjacent Table Mountain.

A careful examination of these hills convinces me that they occupy the site of the rent through which a large part if not all the melted trap came, which doubtless once covered a large portion of this district adjacent to the foot-hills, but of which only comparatively small portions have escaped destructive erosion. These small portions now cap the two Table Mountains and form the small group of hills here referred to. This outburst took place directly in line of the upturned edges of the Cretaceous strata against the flanks of the Rocky Mountains, the position and extent of which have already been explained. This dynamic movement, however, did not materially affect the strata of either the Red Beds or the Dakota Group, as is shown by the present direct continuity of the crests of their hogbacks. The strata of the Colorado Group are too soft to produce a hogback, and they are so covered by *débris* that we cannot know to what extent they may have been disturbed by the outburst. The hogback of the Fox Hills Group has been disturbed and interrupted. A portion of it standing conspicuously in the valley at a point not far to the southwestward from the coal-shaft in question has its strata nearly vertical, instead of standing at the much less angle of elevation shown by the other hogbacks, when, if undisturbed, since the mountain uplift they should be the steeper, because they are nearer to the foot-hills. The trend of this short hogback of Fox Hills strata is also so deflected that if a line representing its axis were continued in the curve it indicates in a northward and northeastward direction it would lie approximately tangent to the southeastern base of the group of trap hills here referred to, near the point where the coal-shaft has been sunk.

I offer the following explanation of these phenomena: The trap rent was a very large one, not in the form of a dike, but circumscribed, irregular, and several hundred yards across. It came in the line of flexure of the Cretaceous strata where they are upturned against the flank of the mountains, probably breaking through those of the Colorado Group, but evidently lifting, displacing, and *overturning* at least a portion of the Fox Hills strata, together with a portion of the then and there superimposed Laramie strata. This is believed to be the exact condition of those adjacent to the trap hills, through which the coal-shaft has been

sunk. That is, the strata at that particular point have been entirely reversed by the uplifting force of the outflowing trap; so that the shaft was begun in strata of the Fox Hills Group and continued downward until those of the Laramie, including the coal, were reached in reversed order.

This bed of coal is believed to be the same that is now worked in the Laramie strata of Table Mountain near Golden City, its change of thickness and quality within that distance not being unusual with the coal-beds of the Laramie Group.

This explanation makes it evident that *Cyrena? holmesi* Meek is a Cretaceous instead of, as Meek supposed, a Tertiary fossil, even without the conclusive testimony of the associated *Scaphite.*

Besides this, by carefully cutting away the embedding shale from an authentic specimen of that species, which I obtained from the same layer that furnished the type specimens, I discovered that it has not the hinge characteristics of *Cyrena*, but has those of *Mactra*, or at least of a section of that genus; thus confirming the marine character of the stratum containing it, which was indicated by the associated *Scaphite.* These facts alone would seem to be sufficiently conclusive, but within the last few months Mr. Lakes has sent to the office of the Survey some specimens of the *Cyrena? holmesi* of Meek, collected by him from the Fox Hills strata on Bear Creek, near Morrison, about twelve miles southward from the place where that species was originally discovered. The shells sent by Mr. Lakes were imbedded in a small mass of stone, and imbedded in the same mass I also found a fragment of a *Scaphite*, evidently of the same species as that which was found in the layer that furnished the type specimens of *Cyrena? holmesi*, on Ralston Creek. It also contained a fragment of a *Baculite.* These facts are conclusive as to the Cretaceous age of Mr. Lakes's fossils, even without the field-label, which was "Bear Creek, 750 feet below the coal-bed." The coal-bed referred to is that of the Laramie Group and which is not far from its base.

The questions of interest involved in the discussion of the phenomena observed in connection with the fossils of the coal-shaft on Ralston Creek are in part purely geological and in part paleontological, and some of them are so important that the subject has here received more attention than would otherwise have been given to it.

The location of the great trap vent upon the line of flexure of the strata, which are upturned against the flank of the Rocky Mountains, would seem to indicate that the outburst came there because of the weakening of the strata by having been flexed, thus lessening the resistance to upward pressure. But while the strata are continuously flexed along the base of the mountains, the vent is circumscribed, and is not in the form of a dike, nor a lengthened sheet along the line of flexure. Besides this, the dike at Valmont, fifteen miles to the northward, is not upon, but several miles eastward of, the line of flexure, and at right angles to it. It is doubtless true that the inclined posture of the strata, when the trap burst through, facilitated the overturning of those that were upon the outer side of the vent; those between the vent and the granite mass of the mountains offering greater resistance to the pressure were comparatively undisturbed.

It is also desirable to elucidate every question which bears upon the order of succession of the brackish- and fresh-water deposits upon those of marine origin, and the consequent order of succession of invertebrate types. Coal-making conditions are known to have existed at times in both the Colorado and Fox Hills Cretaceous epochs, in what are now the regions west of the Rocky Mountains, but they are believed not to

have existed during either of those epochs within what are now the limits of Colorado, east of those mountains. The foregoing explanation of the phenomena observed on Ralston Creek removes the doubt upon this point that was at one time felt in consequence of finding Cretaceous fossils above a bed of coal there. At all the localities which I have visited in Eastern Colorado the strata of the Colorado, Fox Hills, and Laramie Groups all indicate great uniformity of condition of deposition throughout each epoch respectively, to which rule the formerly-supposed presence of a bed of coal in the Fox Hills strata at Ralston Creek would, if true, have been an exception. A comparison of these indications of former physical conditions in regions that are now respectively east and west of the Rocky Mountains, will be made on subsequent pages, but it should be always borne in mind that this great physical continental feature did not then exist.

The following list of fossils obtained from Cretaceous strata near the base of the Rocky Mountains, between Bear and Ralston Creeks, a distance of about twelve miles and including the vicinity of Golden City, has been collected in part by Mr. A. Lakes and Capt. E. L. Berthoud, but I also visited all the localities in person. The strata of the Red Beds, the Jurassic and Dakota Groups of this district have been long and carefully searched for invertebrate fossils by both these gentlemen, but without success, except the discovery of a single shell which is reported by Mr. Lakes, presently to be mentioned.

LIST OF CRETACEOUS FOSSILS FROM THE VICINITY OF GOLDEN CITY AND MORRISON, COLO.

Fox Hills Group.

1. *Pteria linguiformis* Evans & Shumard. Bear Creek, near Morrison.
2. *Pteria* (*Pseudoptera*) *fibrosa* Meek & Hayden. Bear Creek, near Morrison.
3. *Inoceramus oblongus* Meek. Bear Creek, near Morrison.
4. *Nucula planimarginata* Meek & Hayden. Near Golden City.
5. *Nucula cancellata* Meek & Hayden. Near Golden City.
6. *Cardium speciosum* Meek & Hayden. Bear Creek, near Morrison.
7. *Tellina scitula* Meek & Hayden. Bear Creek, near Morrison.
8. *Mactra holmesi* Meek sp. Bear and Ralston Creeks.
9. *Pachymya? herseyi* White. Bear Creek, near Morrison.
10. *Dentalium gracile* Hall & Meek. Bear Creek, near Morrison.
11. *Lunatia subcrassa* Meek & Hayden. Bear Creek, near Morrison.
12. *Baculites ovatus* Say. Bear Creek, near Morrison.
13. *Scaphites nodosus* Owen. Bear Creek, near Morrison.
14. *Scaphites mandanensis* Morton sp.? Bear and Ralston Creeks.
15. *Placenticeras placenta* var. Bear Creek, near Morrison.

Colorado Group.

16. *Ostrea congesta* Conrad. Bear Creek, near Morrison.
17. *Inoceramus deformis* Meek. Bear Creek, near Morrison.
18. *Inoceramus problematicus* Schlotheim. Bear Creek, near Morrison.

NOTES ON THE FOSSILS FROM THE VICINITY OF GOLDEN CITY AND MORRISON.

The fossils obtained from the strata of the Fox Hills Group at Bear Creek were found at two horizons or in two layers; one about two hun-

dred feet below the bed of coal there, and the other about seven hundred and fifty feet below it. The coal is embraced within the strata of the Laramie Group, and is apparently not much more than one hundred feet above its base, but no plane of demarkation between the two groups has yet been satisfactorily recognized. Nos. 6, 7, 9, and 10 of the foregoing list were obtained from the upper fossiliferous horizon on Bear Creek, and they are also all characteristic of the uppermost strata of the Fox Hills Group as seen in the valley of the Cache à la Poudre and at the mouth of the Saint Vrains, and the upper Bear Creek horizon is therefore no doubt equivalent with those strata. The species represented by the four foregoing numbers are discussed in the notes following the lists of fossils collected in the district of the Cache à la Poudre and Saint Vrains. The two species of *Nucula* represented by Nos. 4 and 5 of the list were obtained from near Golden City by Captain Berthoud. They also exist in the uppermost fossiliferous strata of the Fox Hills Group in the valley of the Cache à la Poudre, but in the Upper Missouri River region No. 5 at least ranges as low as the upper part of the Fort Pierre Group. All the remaining species of the list that were found in the Fox Hills strata of Bear Creek are from 750 feet below the coal. The existence and association of the *Cyrena? holmesi* of Meek (=*Mactra holmesi* White) and *Scaphites mandanensis?* at both the Ralston Creek and Bear Creek localities has already been stated and commented on.

The three species obtained from the Colorado Group at Bear Creek are from the upper portion, doubtless representing in part the Niobrara Group or Cretaceous No. 3 of the Upper Missouri section. The specimens of *Ostrea congesta* were found adhering to the shells of *Inoceramus deformis*. The former is an abundant and widely-distributed species, but the latter has never, to my knowledge, been found in the Upper Missouri River region, although it is common in the latitude of Colorado and southward. *Inoceramus problematicus*, No. 18 of the list, does not appear to range above the horizon at which it is found in the valley of Bear Creek, east of the Rocky Mountains in Colorado, but in Southwestern Wyoming forms that are undistinguishable from this species are found in strata of the Fox Hills Group.

The discovery by Mr. Lakes of a fossil shell in the strata of the Dakota Group has been already referred to. The following is his account of it in a personal letter to me under date of June 21, 1878: "To-day in exploring some rocks of the Dakota Group, I found in some finely laminated drab shales about 100 feet below the usual ridge of sandstone which so characteristically caps the Dakota hogback, the shell which I forward to you by to-day's mail. The shell was found in undoubted Dakota rocks, a little north of the river Saint Vrains." This is quite an unexpected discovery, and the specimen is the first *Inoceramus* that has, so far as I am aware, been found in strata of the Dakota Group. From the above remarks of Mr. Lakes, and a pencil-sketch which accompanied them, it seems probable that the shell in question really came from the upper layers of the Atlantosaurian beds of Professor Marsh. It has been much compressed, and is too imperfect for specific identification, and is perhaps identical with *I. umbonatus* Meek & Hayden, a Fort Benton Group species, but it has in its compressed condition much the aspect of *I. vanuxemi* Meek & Hayden, from the Fort Pierre Group. It is of a decidedly Cretaceous, and not Jurassic type, which fact has an interesting relation to the age of the Atlantosaurian beds of Professor Marsh, if the specimen really came from them.

The deposition of sediment which formed these beds seems to have been continued without interruption or material change of character to

the formation of those layers in which Mr. Lakes found the *Inoceramus* here referred to; and the Atlantosaurian beds seem also to be a part of a continuous deposition of sediment from those of undisputed Jurassic age beneath. This subject will be again referred to on subsequent pages, but our present knowledge is hardly sufficient to warrant any conclusive generalizations upon it.

From Ralston Creek I proceeded northward along the base of the foot-hills, by way of Marshall's coal mines to the valley of the South Boulder. Going thence eastwardly, I found in the slope of the hills some two or three miles eastward from Marshall's mines at about 50 feet above the horizon of the coal some imperfect specimens of oyster-shells. They were, however, perfect enough to allow their identification with *O. glabra* which I had found so abundant at several localities of Laramie strata, as already recorded.

Continuing eastward to the village of Erie, on Coal Creek, I found, just south of the village and of the coal mines which are worked there, some considerable exposures of Fox Hills strata that have evidently been brought up by a fault. I could not ascertain the extent of this fault because of the presence of the abundant *débris* of the plains, but it seems to be a short one and to have its northern end at the south side of the village, and to extend southward only between one and two miles. The throw of the fault is a slight one compared with many of those which we find west of the mountains, as the fossils indicate a horizon near the upper part of the Fox Hills Group, and the layers containing them are on a level with the coal, which is not far from the base of the Laramie Group. The fault is thus seen to involve the upper strata of the Fox Hills Group and the lower strata of the Laramie, and the throw probably does not exceed 500 feet. The fossils referred to are in the form of casts in sandstone, and consist almost wholly of *Veniella humilis* Meek & Hayden.

I traversed in different directions a large part of the district between South Platte and Boulder Rivers, hoping to find other exposures of the fossiliferous horizons of Laramie strata, but without success. These examinations ended my paleontological field-work east of the mountains for this season, and I returned to the foot-hills at Boulder City to prepare for crossing the Rocky Mountains by way of Boulder Pass. Many interesting and important paleontological questions pertaining to this eastern region still remain unsettled, the investigation of which I hope to resume at another time. I have also passed over many important features of structural geology without comment because they have already been so fully reported upon by Dr. Hayden and the late Mr. Marvine.

The following brief summary of the observations made east of the mountains is presented here for the purpose of facilitating the discussion that on subsequent pages will follow the record of the field-work for the whole season.

Every practicable opportunity was improved to note the character of the strata at the junction of the well-recognized groups respectively, and also to seek for the precise point or plane where the characteristic fossils of the one cease, and those of the other begin, to appear. Also, as far as possible, the vertical range of each species collected was observed and compared with the vertical range of the same and associated species elsewhere, especially with those from the typical localities of the Upper Missouri River region.

As to the limits of the formations or groups which I have examined, although each one as a whole is sufficiently distinct and characteristic lithologically, and also paleontologically when fossils occur in them, the

precise boundaries of all of them, from the base of the Red Beds to the top of the Monument Creek Group, were found to be obscure, even where they could be best observed. It is true that the opportunities for such observation are limited by prevailing *débris*, but in no place where opportunity has offered have I been able to select any stratum or any line or plane of demarkation between any two strata, and say with confidence that it constitutes the precise boundary between any two of these groups or formations. Besides this, the horizons which are indicated by the presence, or known vertical limits of range, of certain species of fossils are all parallel with the assumed planes of demarkation between the groups, and consequently with each other. Thus, for example, a well-characterized fossiliferous horizon occurs near the top of the Fox Hills Group and another near the base of the Laramie Group, both being constant throughout a large part of this region. They are comparatively near together, no distinct plane of demarkation existing between the two, as before stated, and yet no two fossiliferous horizons in any series more plainly belong to different groups. In the present state of our knowledge edge it is perhaps too much to say positively that sedimentation was continuous and uninterrupted over the area that now constitutes the region I have examined, from the beginning of the epoch of the Red Beds to the close of the Laramie period, and, perhaps, also, to the close of the Monument Creek epoch, but such now seems to have been the case. That oscillations of land-level took place within that time, which shifted the eastern, and doubtless other shore-lines of then existing seas, is certain, as will be hereafter shown, but such oscillations do not seem to have interrupted or materially affected the continuity of sedimentation in the area that now constitutes the portion of Colorado which lies east of the Rocky Mountains. Important physical changes of course took place elsewhere, which had their effect in producing the changes of the faunæ of the passing epochs which are represented by the groups in question, and in defining those epochs themselves, but that subject will be briefly discussed on following pages. The observations which I made there indicate that all the movements which resulted in the elevation of the Rocky Mountain range certainly took place after the close of the Laramie period, and at least in large part after the close of the epoch of the Monument Creek Group.* The faults and trap outflows, however, that have just been noticed, took place at a much later epoch, probably as late as the Pliocene Tertiary, and were probably contemporaneous with a large part of those that are found on the west side of the Rocky Mountains.

Before taking leave of the east side it is proper to refer to certain drift phenomena which I observed along the eastern base of the mountains, because I shall also have occasion to refer to this subject briefly when treating of regions farther westward.

Near the base of the mountains, and sometimes reaching several miles out upon the plains, are beds of drift, composed of gravel, usually coarse, and small bowlders. Almost without exception, this material is com-

---

* As to whether the Monument Creek Group is really conformable upon the Laramie, I can only say that it appeared to be so where I examined it. It is probably a considerably later deposit than the Laramie.

There is, as reported by the late Mr. Marvine, a limited unconformity of the Laramie strata upon those of the Fox Hills Group in Middle Park; but that is believed to have been caused by comparatively slight movements that took place previous to those of the Rocky Mountain uplift proper. Very extensive displacements, however, are known to have taken place at or near the close of the Laramie period in the region that now constitutes the western portion of Green River Basin, as will be shown on following pages; but even those movements are believed not to have interrupted continuous sedimentation in comparatively large areas.

posed of fragments of granitic and metamorphic rocks like those composing the immediately adjacent mountains. These beds have been much removed by later erosion, the approximately level portion, not eroded, being from 200 to 300 feet above the neighboring streams. Sometimes they break off by terrace slopes that are apparently not caused by erosion. The higher surfaces of the deposit have a slight uniform slope toward the plains. It is difficult to estimate the thickness of the deposit even approximately, and it is also difficult to ascertain whether the stratified rocks upon which it was deposited were first leveled off to receive the deposit, or whether the leveling was only of its own upper surface. Its appearance suggests that it may have been deposited by a formerly existing ice-sheet moving off from the immediately adjacent mountains, but there are some facts connected with it that are difficult to explain in connection with that suggestion. High hogbacks of Mesozoic rocks stand between those nearly level reaches of drift and the granite rocks that furnished the material of which it is composed. If the surface of the drift was really leveled off by an outwardly moving ice-sheet, it is difficult to understand why the hogbacks were not also reduced to the same plane. But they stand there, immediately adjacent, several hundred feet above the surface of the drift, and also above many of the adjacent granite foot-hills, and, so far as I could discover, they show no signs of former glacial action upon them.

Again, the source of the material of which the drift is composed is only from two to ten miles away, and yet its gravel and bowlders are as perfect and smoothly rounded as the water-worn pebbles of a sea-shore. They evidently have a history beyond that of mere detachment from their original ledges and a few miles of glacial transportation. But this subject will be again referred to on subsequent pages, though perhaps not elucidated.

Passing through the foot-hills near Boulder City, consisting mainly of the great hogbacks of the Red Beds and Dakota Group, we left all the sedimentary rocks of the east side and traveled upon the great granite nucleus of the Rocky Mountains until we had crossed the Front, or principal range. Crossing this by way of Boulder Pass, we reached the large, elevated intra-mountain region known as Middle Park. Our journey led us into the park by way of the headwaters of Frazier River, where we came upon the first stratified rocks after leaving the east side, which were the "Lake Beds" of Dr. Hayden's reports.

The geological structure of the park having been so ably reported upon by the late Mr. Marvine, my attention was more especially directed to the characteristics of the Laramie strata and the Lake Beds, with the hope of learning something of their paleontological history. The latter deposit is very extensively developed in the park and occupies a large part of its surface. It rests unconformably upon all the other rocks, from the granite to the Laramie strata inclusive.

The strata (for it is distinctly stratified) generally presents a nearly level aspect, but the original upper surface of the deposit has been everywhere removed by erosion; so that of an original thickness of a thousand feet or more, scarcely more than one-third of that thickness is now found at any one point. While the strata of this deposit have nowhere been so much displaced as all the other stratified rocks of the park have been, they have, however, been in many places tilted at angles varying from one to fifteen degrees. This deposit was carefully searched for fossils at all the points which I visited, but without success except at one point on Ranch Creek, a tributary of Frazier River. Here I found two imperfect specimens of a species apparently belonging to the genus

Helix; and imbedded in the same mass a small metacarpal or metatarsal bone, about one centimeter long, and apparently belonging to a small rodent. These give no indication of the age of the deposit, because they belong to common living types, and because fossil forms of living invertebrate types are abundant in strata as old as those of the Laramie Group. We must, therefore, rely upon other phenomena to indicate the age of this deposit. The following is a summary of the conditions and indicated circumstances bearing upon this point:

The Lake Beds are known to be considerably more recent than the Laramie Group, because the former rests conformably upon the flexed and much-eroded strata of the latter. The deposit is a circumscribed one, evidently of fresh-water origin, occupies only the lower surfaces of the park, and has plainly derived its material from the immediately adjacent and surrounding hills, but doubtless before either the deposit or the hills were elevated to their present height above the level of the sea. On the other hand it is known to be quite ancient as compared with the present time, because it has suffered extensive erosion, evidently amounting to more than half its original bulk. It bears the evidence of drift-leveling similar to that which has been already noticed as occurring at the eastern base of the mountains, and is consequently older than the epoch of that drift; and its strata have been considerably flexed in some places, showing that mountain elevation was continued after its deposition. This deposit is regarded as of the same or about the same age as the one found west of the mountains which has been called the Brown's Park Group by Professor Powell, and Uinta Group by Mr. King. A comparison of the two was made in my report of last year, and reference to the subject will necessarily be made on following pages.

The drift phenomena observed in Middle Park consist of scattered gravel and bowlders upon quite extensive, nearly level, or gently sloping surfaces of different heights, which often assume the character of terraces. The gravel and bowlders are sometimes scantily and sometimes profusely spread, and the material of which they are composed has evidently been derived from the immediately adjacent mountains and hills. The pebbles and small bowlders have been as smoothly rounded, evidently water worn, as those which have already been referred to as existing at the eastern base of the mountains. The leveling of the surfaces upon which this material rests may have been produced by the same forces which scattered it, but the evidence on this point is not conclusive. The various aspects in which one may view these surfaces in different portions of the park suggest the idea that they may represent different base-planes of erosion which were successively reached during the process of erosive excavation of the deposits which formerly more completely than now filled the park. This terracing of the deposits of the park is known to be of comparatively recent date, because they occur upon the older and later deposits alike, and even the higher or older terraces or levels are, in many cases, upon the Lake Beds, which are much the latest of the formations.

In Egeria Park, which lies west of Middle Park and of the Park Range of mountains, these drift terraces or levels are very extensive, and constitute even more conspicuous features of that district than they do in Middle Park, but they are there mainly or wholly carved out of the Cretaceous deposits, there being no later deposits within its limits.

The strata of the Laramie Group are abundantly developed in Middle Park, so far as aggregate thickness is concerned, which is fully double that of the strata of the same period in the region which I examined

adjacent to the eastern base of the mountains. They occupy a large area in the mountain region between the Front and Park Ranges, extending from near the southern portion of Middle Park to the southern portion of North Park, and including the hill region between both. It has been searched for fossils by every geological party that has visited it, but, so far as Middle Park is concerned, without success except as to fossil plants.

Among the collections of the survey are some fossils obtained by the late Mr. Marvine, from strata that have been referred to the Laramie Group, in North Park, accompanied by the following label: "North Park, SW. corner, 8 miles from Muddy divide." "Muddy divide" is doubtless the locality which is designated as "Muddy Pass" on the maps of the Atlas of Colorado, lately published by the survey. The fossils referred to consist of two, or perhaps three, species of gasteropods, which are in a partially crushed and imperfect condition of preservation, being in the form of casts in soft sandstone. One is a *Viviparus*, the specimens of which are remarkably like some of those of *V. wyomingensis* Meek, which I have collected from the Bridger Group, in a similar state of preservation; but there is nothing in the observable characters of these specimens that would forbid a reference of them to *V. Reynoldsianus* Meek & Hayden, from the Fort Union Group of the Upper Missouri River region. The correctness of the latter reference, rather than the former, is suggested by the fact of the known identity of the Fort Union beds with the Laramie Group; and also the further fact that *V. Wyomingensis* has not been recognized in any other strata than those of the Bridger Group, not even those of either the Green River or Wasatch Group.

Of the other species, one is referred to *Campeloma*, and is probably identical with *C. multistriata* Meek & Hayden, from the Fort Union beds, and also found by myself in the Laramie strata of Crow Creek Valley.

The other form is somewhat more elongate than the last, and has a slight angularity at the outer side of its body volution. It perhaps belongs to the genus *Goniobasis*, but neither its generic or specific characteristics could be clearly distinguished. These are all the invertebrate fossils that are known to have been collected from any of the strata of this large intramountain area that have been referred to the Laramie period. Of themselves they are not sufficient to determine the age of the strata containing them, or their equivalency or otherwise with those of the Laramie Group. The strata of all the other areas which in this report are referred to the Laramie period are, as I shall show, so referred because of the specific identity of a greater or less number of species of invertebrate fossils found in the strata of the different areas or regions respectively. This paleontological evidence is in all cases corroborated by the stratigraphical relations of the Laramie strata with those of the Fox Hills Group beneath, and also, in some cases, with other groups above. In the case of the strata of Middle Park of assumed Laramie age, we are reduced to the latter kind of evidence alone, if we except that which may be derived from the fossil plants and the few fossil shells before mentioned.

While we seem warranted in assuming that the strata in question, of the Middle Park region, are really equivalent with the Laramie Group of the Upper Missouri, the great Green River Basin, and of the plains at the eastern base of the Rocky Mountains, the following comparisons are of interest.

The strata in question have an aggregate thickness in Middle Park

fully double that of those in the plains at the eastern base of the Front Range, but not greater than that at the western base of the Park Range. The Middle Park strata contain no fossils that are certainly identical in species with any of the numerous forms found on each side of that region at the eastern and western bases, respectively, of the Rocky Mountains; and they contain, so far as known, only those imperfectly known species before referred to that are possibly identical with forms in the Fort Union beds of the Upper Missouri.

So far as I am aware, no coal has been found in the Laramie beds of Middle Park, while it is more or less abundant in all the other known regions of that group.

In connection with this latter fact it may be mentioned that Mr. Marvine found a bed of coal in the Fox Hills strata of Middle Park, and it is well known to exist in strata of that age west of the mountains, but none has ever been found in strata of the same age east of the mountains in Colorado, so far as I am aware.

Leaving Middle Park I crossed the Park Range to the headwaters of Yampa River, by way of Egeria Park.

Owing to want of time, comparatively little was done in the examination of the Cretaceous Groups of Middle Park, except to identify them as unmistakably equivalent with the groups of that period as recognized elsewhere in Colorado, both east and west of the Rocky Mountains. In my generalizations, I shall therefore make use of the observations that have been made by Hayden, Powell, and Marvine in this district. I found limited exposures of these groups in connection with the Laramie Group in the vicinity of Hot Sulphur Springs in the middle portion of the park, and also farther westward. Passing down the valley of Grand River, only the Lake Beds were observed within immediate view from my line of travel, until we reached the valley of Muddy River, a northern tributary of the Grand, that has its course along the western portion of the park. Here the strata of the three Cretaceous Groups are exposed along the valley of the Muddy and also flanking the neighboring eastern base of the granite nucleus of the Park Range, the Red Beds only intervening. Crossing their outcrops, I passed over the Park Range into Egeria Park, where I found, at the western base of the range, as at its eastern base, the Red Beds resting upon the granite, and these in turn overlaid by the Dakota and Colorado Groups.

The strata of the latter groups occupy nearly the whole of Egeria Park as well as an adjacent part of the valley of the Yampa, but they are here and there capped with basalt, consisting of shreds of the great sheet that once doubtless covered the whole region of the headwaters of the Yampa and White Rivers. The strata of the Colorado Group in the park and adjacent neighborhood consist largely of light-colored sandstones, often only slightly compacted. In some parts, however, the group here consists of the characteristic bluish sandy shales.

After passing a few miles down the valley of the Yampa, we crossed over in a northwesterly direction, to Terrible and Sage Creeks. In the valley of the last-named creek, near the crossing of the wagon road, I found an exposure of Cretaceous strata. Judging from their lithological aspect I was at first disposed to regard them as belonging to the Colorado Group, but the position of the outcrop, not more than 200 feet beneath the base of the Laramie Group, the strata of which are seen in the adjacent hills, forbade such a reference. The exposure consists of about thirty feet in thickness of light-bluish, grayish, and dark carbonaceous shales, with occasional compact concretions of calcareous and argillaceous rock. In these concretions I obtained the fossils of the following list, most of which are of well-known species.

LIST OF CRETACEOUS FOSSILS COLLECTED ON SAGE CREEK, AN UPPER TRIBUTARY OF YAMPA RIVER, COLORADO.

1. *Caryophyllia egeria* White.
2. *Lingula nitida* Meek & Hayden.
3. *Pteria linguiformis* Evans & Shumard.
4. *Inoceramus barabini* Morton.
5. *Inoceramus pertenuis* Meek & Hayden ?
6. *Nucula planimarginata* Meek & Hayden.
7. *Thetis ? circularis* Meek & Hayden.
8. *Teredo* ——— *?* (borings in fossil wood).
9. *Anisomyon centrale* Meek.
10. *Baculites ovatus* Say.
11. *Scaphites nodosus* Owen.

NOTES ON THE CRETACEOUS FOSSILS OF SAGE CREEK.

The fossils of this list, unless otherwise stated, are described and figured in vol. ix, United States Geological Survey of the Territories.

1. *Caryophyllia egeria* White.

This species was newly discovered with the fossils of the foregoing list, and is described and figured in another part of this volume, together with the only other known species of this genus that has yet been discovered in American Cretaceous strata. The latter was discovered by Professor St. John, in strata of the Fox Hills Group, at Cimarron, N. Mex., and in similar argillaceous strata. This circumstance seems to be worthy of note, in view of the fact that the usual habitat of living corals is in the purest waters; and the comparatively pure calcareous strata that inclose most fossil corals indicate that similar conditions have always been essential to their abundant growth. Coming, as this species does, from near the top of the series of Fox Hills strata, it adds to other evidence that true marine conditions were continued up to the close of that epoch.

2. *Lingula nitida* Meek & Hayden.

A single example only of this species was found. Only one other species of the genus has been recognized in the Cretaceous rocks of the West, both having been first discovered in the Upper Missouri River region, and both are rare, but widely distributed.

3. *Pteria linguiformis* Evans & Shumard.

On a previous page of this report, this species has been noticed at some length. It is widely distributed, and ranges through both the Fort Pierre and Fox Hills Groups, in the Upper Missouri River region.

4. *Inoceramus barabini* Morton.

Scarcely any Cretaceous species has a wider range in Western North America than this. Its vertical range is also through the Fort Pierre and Fox Hills Groups of the Upper Missouri River region, and Mr. Meek has described a variety of it from the uppermost strata of the Fox Hills Group, at the mouth of Judith River.

5. *Inoceramus pertenuis* Meek & Hayden.

A couple of imperfect examples of *Inoceramus* were found among the other fossils that seem to belong to this species, although it is possible they may belong to the *I. vanuxemi* of Meek & Hayden. The last-named species has been found only in the Fort Pierre Group of the Upper Mis-

souri River region, and it also ranges low in the strata of the Fox Hills Group of Eastern Colorado. In view of the high position of these fossils, it seems probable that the examples in question belong rather to *I. pertenuis* than to *I. vanuxemi.*

6. *Nucula planimarginata* Meek & Hayden.

Several examples of this species were found here, all imperfect, but all showing characteristic features. It is always found to range high in the Fox Hills strata of Colorado.

7. *Thetis ? circularis* Meek & Hayden.

Two or three imperfect examples were found, which seem, from their external characteristics, to belong to this species, although they are all smaller than the type specimens. The latter also have been found only in the Fort Pierre Group of the Upper Missouri River region, while those in question hold a much higher position.

8. *Teredo* ——— ?

These examples consist only of some borings in pieces of fossil wood which have become filled with stony material; but they seem without doubt to have been made by a species of *Teredo* or an allied mollusk.

9. *Anisomyon centrale* Meek.

A single example only of *Anisomyon* was found with the other fossils of this collection. It doubtless belongs to this species, although it shows a greater than the usual number of the irregular radiating grooves which characterize most of these forms. Figures of Meek's types of this species are given in another part of this volume.

10. *Baculites ovatus* Say.

In the notes upon this species on a previous page it was stated that its vertical range was not known to extend, either in the upper Missouri River region or in Eastern Colorado, to the uppermost strata of the Fox Hills Group. At the locality in question, however, as well as at another locality also west of the mountains, in the valley of White River, presently to be mentioned, it ranges not only into the uppermost strata of the Fox Hills Group, but it is there associated with species that especially characterize the uppermost strata of that group elsewhere.

11. *Scaphites nodosus* Owen.

Four or five examples of this species were obtained at the locality here discussed, one of which possesses all the characteristics of the variety to which Mr. Meek gave the name of *plenus.* The others are by natural growth so much compressed laterally that they might be readily mistaken for a separate species. They appear, however, to possess the essential characteristics of the form to which Mr. Meek gave the varietal name of *quadrangularis*, except that they want the flattened periphery, bordered by numerous small nodes, which characterizes his type of that variety.

While discussing the fossils of the Fox Hills Group, which were collected east of the mountains in Colorado, it was shown that certain of the species characterize certain horizons in the great group. For example, certain species that are found only in the Fort Pierre Group of the Upper Missouri River region, are found only at a correspondingly low horizon in the consolidated Fox Hills Group as it is developed in Eastern Colorado. Also, that the species which characterize the uppermost Fox Hills strata in one of those regions are, as a rule, equally characteristic of corresponding strata in the other. While these facts

are very valuable for general application, the known great vertical range of some of the species makes it impracticable to place implicit reliance upon any single species as indicating a definite limited horizon within the group. The following comparisons and references will show how far the paleontological indications agree with the known stratigraphical position of the fossils in question. According to our present knowledge of the range of the species of the Fox Hills Group, the presence of *Scaphites nodosus* among these fossils indicates for them a low horizon in the Fox Hills Group, as does also *Thetis? circularis*, if that species has been correctly identified.

On the other hand, all the others may be regarded as ranging through the whole upper half of the Fox Hills Group in Colorado, and some of them below it, including *Baculites ovatus*, which, as before stated, ranges higher upon the west side of the Rocky Mountains than it is known to do upon the east side. Besides this, *Inoceramus pertenuis*, which is doubtfully identified here, is a species hitherto known only in the uppermost strata of the Fox Hills Group in the Upper Missouri River region; and a variety of *I. barabini* also exists in the same strata. Summing up the whole paleontological evidence then, it is seen that while it is suggestive of a lower horizon, there is nothing to prove that the strata containing these fossils may not really belong, as they appear to do, to the uppermost portion of the Fox Hills Group. Therefore we need not assume that the strata of the last named group were in any degree removed by erosion in this neighborhood before the deposition of the Laramie strata. Careful examination at the junction of the two groups in the neighboring hillsides also failed to discover any plane of demarkation between them. This fact has the same general application in this region west of the mountains that it was found to have at their eastern base.

No other fossiliferous horizons were found in this neighborhood, either in the Fox Hills or Laramie Groups. My journey led me down the valley of the Yampa, during which I passed much of the way over Laramie strata, as determined by their stratigraphical position and characteristics, as far down as opposite the confluence of Williams River before I found any fossils to confirm those previous conclusions. From this point to one about seven miles below, in the north valley side of the Yampa, I found somewhat frequent exposures of fossiliferous layers, the principal of which was found in Cañon Park, a portion of Yampa Valley. The fossils collected here will be treated as from one locality, because they are practically upon one horizon and essentially the same species of fossils occur at each locality, except two or three limited ones, where no others besides the *Ostrea* were found.

LIST OF LARAMIE FOSSILS COLLECTED IN YAMPA VALLEY, NEAR CAÑON PARK, NORTHWESTERN COLORADO.

1. *Ostrea glabra* Meek & Hayden.
2. *Anomia micronema* Meek.
3. *Anomia gryphorhynchus* Meek.
4. *Volsella* (*Brachydontes*) *regularis* White.
5. *Corbicula occidentalis* Meek & Hayden.
6. *Corbicula* (*Leptesthes*) *fracta* Meek.
7. *Corbula subtrigonalis* Meek & Hayden.
8. *Neritina volvilineata* White.
9. *Melania wyomingensis* Meek.
10. *Viviparus plicapressus* White.
11. *Campeloma multistriata* Meek & Hayden.

NOTES ON THE LARAMIE FOSSILS OF YAMPA VALLEY.

The fossils of this list occupy a distinct horizon of limited vertical extent and probably not more than four or five hundred feet below the top of the Laramie Group. The *Ostrea*, however, appears to have a greater vertical range than the other fossils of the list do, as I found a few examples of it in different places, from one to two hundred feet below the horizon of the other species. All the species appear to be intimately associated together, except that the gasteropods appear to be mainly or wholly confined to a single layer, but that layer has other layers containing the other fossils, both above and below it.

1. *Ostrea glabra* Meek & Hayden.

Most of the specimens of this species which were obtained in Yampa Valley are comparatively large, massive shells, being fully adult. They are in all respects like those which have been obtained from the same horizon at Point of Rocks, something more than 100 miles to the northwestward, and which were described by Meek as *O. wyomingensis*. It has been shown on a previous page that in the Laramie strata of Eastern Colorado intermediate forms are found associated with typical forms of *O. glabra* and *O. wyomingensis* that connect these two types unmistakably. I therefore retain the name *O. glabra* as having priority of date, although it is seldom that any specimens are found in the Laramie strata west of the Rocky Mountains that closely resemble the types of *O. glabra* which were selected for illustration by Meek and Hayden. This species is extremely variable, even for one of the genus *Ostrea*, and there is much reason to believe that not only *O. glabra* Meek & Hayden, *O. subtrigonalis* Evans & Shumard, *O. wyomingensis* Meek, as already suggested, but *O. arcuatilis* Meek and *O. insecura* White also belong to one and the same species. But this subject will be further referred to in connection with a discussion of the collections made in the valley of Bitter Creek.

2. *Anomia micronema* Meek.

The specimens of this species which were obtained in Yampa Valley have a smaller average size than those which were obtained from the Laramie strata east of the Rocky Mountains, and smaller also than those found at Rock Springs in the valley of Bitter Creek, which occur there at a somewhat lower horizon in the Laramie series; but they are doubtless specifically identical at all these localities. See further remarks under the head of notes on the Laramie fossils of Crow Creek on a previous page.

3. *Anomia gryphorhynchus* Meek.

Two or three examples only of this species were found in the Yampa Valley. It is a rare species at all places except the original locality in Bitter Creek Valley. See further remarks under the head of notes on the Laramie fossils of Crow Creek and Bitter Creek Valleys.

4. *Volsella* (*Brachydontes*) *regularis* White.

A couple of fragments only of this species were obtained in Yampa Valley, where they were found mingled with the shells of *Ostrea* and *Corbicula*. The type specimens were found in the valley of Crow Creek, under which head the species is more fully noticed; but it has been recognized at several places west of the Rocky Mountains in Colorado and Wyoming.

5. *Corbicula occidentalis* Meek & Hayden.

This species was originally described by Meek & Hayden from the Judith River Group in the Upper Missouri River region, and it is also

described and illustrated in vol. ix of the United States Geological Survey of the Territories. It is quite abundant at some places in the valleys of the Yampa and Bitter Creek, in the upper portion of the Laramie Group; but although the genus is so well represented east of the mountains in Colorado, this species is not known there. I have at present no doubt of the identity of these Northwestern Colorado and Southern Wyoming forms with the typical forms of the species. There is a possibility that this species is also identical with *C. cytheriformis* Meek & Hayden, originally obtained from the same group and region; but as the differences between the two forms there, as represented by Meek, are repeated in the valley of Bitter Creek, as will be shown on a subsequent page, I prefer at present to regard them as separate species. *C. occidentalis* is a somewhat variable species, and the shell described by Mr. Meek in the An. Rep. U. S. Geol. and Geog. Surv. Terr. for 1872, p. 513, as *C. Bannisteri*, is no doubt specifically identical with it. This view is confirmed by finding forms that are not distinguishable from the type specimen of the latter form among those that are not distinguishable from *C. occidentalis*, and also with associated forms that connect the two. This subject will be further discussed under the head of notes on the Laramie fossils of the Bitter Creek Valley.

6. *Corbicula (Leptesthes) fracta* Meek.

A few imperfect but unmistakable examples of this species were found at the locality in question. The species has been discussed under the head of notes on the Laramie fossils of Crow Creek Valley, and it will be further noticed in connection with the Laramie fossils of Bitter Creek Valley.

7. *Corbula subtrigonalis* Meek & Hayden.

This is one of the most widely distributed species of the Laramie Group, and it has also a considerable vertical range. It was found associated with the two foregoing species in Yampa Valley. Under the head of notes on the Laramie fossils of Crow Creek Valley, its characteristics, distribution, and synonymy are briefly discussed. It is known to occur at two separate horizons in the valley of Bitter Creek, and will be further discussed in connection with the fossils of that district.

8. *Neritina volvilineata* White.

This species has hitherto been found only west of the Rocky Mountains, the only other locality being near Black Buttes station in the valley of Bitter Creek, where the species was originally discovered. The horizon at both localities is practically the same and near the top of the Laramie Group. Most of the specimens found in Yampa Valley are considerably larger than the types, but they are without doubt specifically identical. The species was first described in Powell's Report on the Geology of the Uinta Mountains, p. 131.

9. *Melania wyomingensis* Meek.

A few imperfect examples only of this species were obtained in Yampa Valley. Its horizon here is practically the same as at Black Buttes Station in Bitter Creek Valley, where it was first discovered, namely, near the top of the group. Its great geographical distribution and vertical range have already been referred to, and will be still further discussed on subsequent pages.

10. *Viviparus plicapressus* White.

This species, like its associate, *Neritina volvilineata*, has yet been found only at Black Buttes Station in Bitter Creek Valley, and in the valley

of the Yampa, the horizon being practically the same at both localities. It was first described in Powell's Report on the Geology of the Uinta Mountains, p. 133.

11. *Campeloma vetula* Meek & Hayden.

A couple of imperfect specimens only of this species were discovered in the valley of the Yampa, but they are doubtless identical with those at Black Buttes Station, which I have identified with this species. It was originally discovered in the Judith River beds of the Upper Missouri River region, and is described and figured in vol. ix of the United States Geological Survey of the Territories.

As has before been stated, with the exception of the greater range of the *Ostrea*, the Laramie fossils found in the valley of the Yampa have there a very limited vertical range, probably not exceeding ten or fifteen feet. It was also stated that this horizon is within four or five hundred feet of the top of the Laramie Group. As shown by its fossils and position it is plainly equivalent with the principal fossiliferous horizon at Black Buttes, Hallville, and Point of Rocks Stations in the valley of Bitter Creek, about 100 miles to the northwestward of the Yampa Valley locality; which horizon is also known to be comparatively near the top of the Laramie Group in that region.

With a view to learning all that can be known concerning the junction of this group with the Wasatch Group above it, I spent two days in the vicinity of the north side of Yampa Valley, searching for a plane of demarkation between the two groups, but wholly without success. As a rule, one is usually able to recognize their respective identity without difficulty, by general lithological characteristics; and the fossils of each, when found, leave no doubt as to which of the two groups the strata containing them belong. The differences of lithological character, however, are so little anywhere within a limited vertical range as to offer no suggestion of a boundary plane between formations where I examined them in this region; and, so far as I could discover, all the strata between those which contain characteristic Laramie fossils and those that contain characteristic Wasatch fossils are strictly conformable. It is in view of these facts that I reached the conclusion that whatever of catastrohpal or secular changes may have taken place elsewhere to interrupt sedimentation and mark a boundary between the strata of the Laramie and those of the Wasatch Group or their equivalents (and such are known to have taken place), in this region at least, sedimentation was continuous from the one epoch to the other. This fact, if it be such, has a most important bearing upon the geological history of the North American continent, and which will be discussed on following pages.

The region of the valleys of the Yampa and White Rivers is an important one as regards the development of the Laramie and Fox Hills Groups west of the Rocky Mountains, and for an account of its geological structure I refer to my report for 1876, together with maps published by this survey, and to King's geological map of the Green River Basin, published in advance of his report.

Proceeding down the valley of Yampa River to the vicinity of Yampa Mountain, I made some examinations of the Fox Hills strata, and observations concerning their connection with the Laramie Group. The only invertebrate fossils I found in the neighborhood of that mountain were some fragments of *Inoceramus barabini* Morton, *I. vanuxemi* Meek & Hayden, and *Baculites ovatus* Say. They were found in the neighborhood of the south end of the mountain in upturned strata of the Fox

Hills Group, estimated to be about twelve hundred feet above its base. In the overlying strata of the Laramie Group near by I found an abundance of fragments of plants, but they were too imperfect for specific identification.

Crossing the axial flexure southeastwardly, in the direction of White River Indian Agency, I next examined the Laramie strata among the Danforth Hills. As shown in my report for last year, the strata of the Laramie Group have in this region an aggregate thickness of 3,500 feet; and I am now inclined to regard its thickness as above rather than below that estimate. This is somewhat remarkable when we remember the limited thickness of the group east of the Rocky Mountains, but the thickness of the western Laramie strata is nowhere known to be greater than that of those which are referred to the Laramie Group in Middle Park. I obtained invertebrate fossils from two separate horizons of the Laramie Group in the Danforth Hills, one of which is near the top, and exactly equivalent with the fossiliferous horizon in the valley of the Yampa, some twenty miles to the northward; and the other is 200 to 400 feet above its base; the two horizons being about 3,000 feet apart. The upper horizon I found exposed in the gentle synclinal at the eastern end of the Danforth Hills, about twelve miles due north from the White River Indian Agency, and the lower one about four miles farther westward. The only species found at the upper horizon in the Danforth Hills is *Ostrea glabra*, the species which is so abundant at the same horizon in Yampa Valley and elsewhere; but those of the lower horizon are more numerous and very instructive, as the following list will show:

LIST OF THE LARAMIE FOSSILS FOUND IN THE DANFORTH HILLS, NORTHWESTERN COLORADO.

1. *Anomia micronema* Meek.
2. *Volsella* (*Brachydontes*) *regularis* White.
3. *Volsella* (*Brachydontes*) *laticostata* White.
4. *Nuculana inclara* White.
5. *Corbicula cytheriformis* Meek & Hayden.
6. *Corbicula* ——— ?
7. *Corbicula* (*Leptesthes*) *fracta* Meek.
8. *Corbula undifera* Meek.
9. *Melania wyomingensis* Meek.
10. *Odontobasis? formosa* White.
11. *Cytherina?*
12. *Teliost fish-scales.*

NOTES ON THE LARAMIE FOSSILS OF DANFORTH HILLS.

1. *Anomia micronema* Meek.

The examples of this species are small, as they are in the valley of the Yampa. They are preserved in the form of casts in the compact reddish shale that contains all the fossils of this locality, and show the numerous radiating lines which characterize the species very distinctly. The distinctness and arrangement of these lines in some of the examples strongly recall the appearance of *Orthis* or *Hemipronites* when preserved under similar conditions in paleozoic rocks. The occurrence of this species here, as well as at the other localities already mentioned, shows that its vertical range is practically through the whole great thickness of the Laramie Group.

2. *Volsella* (*Brachydontes*) *regularis* White.

Only fragments of this species were found at this locality, but they seem certainly to be specifically identical with the type specimens from the valley of Crow Creek, east of the Rocky Mountains, and also with those that have been identified with them elsewhere west of the mountains. It is described in the Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iv, p. 707.

3. *Volsella* (*Brachydontes*) *laticostata* White.

This species has been recognized at no other locality. It is described in the same article with the preceding species.

4. *Nuculana inclara* White.

Peculiar interest is attached to this species, not only because it is the first one of the genus and family to which it belongs that has been discovered in the strata of the Laramie Group, but because the whole family is regarded as a purely marine one; while all the other species yet discovered in this group, with perhaps the exception of *Odontobasis*, are regarded as of either brackish or fresh water origin. Only two examples were found, but the condition of their preservation is such that their generic identity is not doubted. It is described in the Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iv, p. 708, and it has been discovered at no other locality. Its own characters, and being also associated with No. 10 of this list (which is probably another marine form) near the base of the Laramie Group, seem to suggest that marine saltness of the waters was preserved in some places for some time after the peculiar conditions of the Laramie period were introduced. This suggestion is somewhat strengthened by the fact that *Odontobasis buccinoides* White holds in the valley of Bitter Creek a position considerably below the principal fossiliferous horizon there, in which both fresh and brackish water forms are found, but none whose living congeners are exclusively marine. It is a singular fact, however, that in both these layers containing marine types specimens of *Melania* were found; but this subject will be discussed at some length on subsequent pages.

5. *Corbicula cytheriformis* Meek & Hayden.

The specimens which I have referred to this species are imperfect, and in the form of casts in the compact reddish shales which contain all the fossils of this locality. A couple of the examples found here indicate a larger size than any of those which have been identified with this species from Bitter Creek Valley, but not larger than the types of Meek & Hayden. These were discovered by Dr. Hayden in the Judith River beds of the Upper Missouri River region, and are figured and described in vol. ix of the United States Geological Survey of the Territories.

6. *Corbicula* ———?

These shales contain casts of another species of *Corbicula* which seems to be different from any described form, but because those examples are yet known only in the form of casts, and are probably not fully adult, they are not specifically named. They resemble young examples of *C. planumbona* Meek.

7. *Corbicula* (*Leptesthes*) *fracta* Meek.

Casts of this species were also found here, which are interesting as showing that it began its existence early in the Laramie period. Heretofore it has been found only in the upper portion of the Laramie Group,

west of the Rocky Mountains; but its position east of the mountains is apparently near the base of the group.

8. *Corbula undifera* Meek.

This species was described by Meek in the Annual Report of the United States Geological and Geographical Survey of the Territories for 1872, p. 513, from the Laramie strata at Rock Springs in the valley of Bitter Creek. In Powell's Report on the Geology of the Uinta Mountains, p. 129, I described another form under the name of *C. subundifera* from a higher horizon of the Laramie strata of the same valley, which I now regard as only a variety of Mr. Meek's species. The original variety has been found only at Rock Springs and at the Danforth Hills locality. The variety *subundifera* was originally found at Point of Rocks in Bitter Creek Valley, and I have also recognized it among some fossils brought from Upper Kanab, Southern Utah, by Professor Powell. The two varieties thus seem to be quite constant.

9. *Melania wyomingensis* Meek.

The wide geographical distribution of this species, as well as its characteristics, has already been commented on under the head of notes on the Laramie fossils of Crow Creek Valley. Its occurrence here not only adds to our knowledge of its distribution, but also to that of its vertical range in the Laramie Group. Its position at the original locality in Bitter Creek Valley, and also at that of Yampa Valley, is near the top of the group. At the Danforth Hills locality its position is near the base of the group, showing the known vertical range of the species to be about 3,000 feet. It is a noticeable fact that all the associates of this species at the Danforth Hills locality are brackish-water, or perhaps in part marine species, none being purely or exclusively of fresh-water habitat. It is also a singular fact that while other fresh-water forms are sometimes associated with it, some of its associates at all the localities where it has been discovered are brackish-water forms, or those that may have inhabited both fresh and brackish waters. The characteristics of the shell are such as to scarcely admit of a doubt that it is either a true *Melania* or a very closely allied form.

10. *Odontobasis? formosa.*

Only a single example of this species was discovered. It is imperfect, and perhaps does not belong to that genus, to which it is referred provisionally. It is published in the Bulletin of the United States Geological Survey, vol. iv, p. 718, and also in this volume, with a figure.

11. *Cytherina?*

In the fine-grained indurated reddish shales of this locality are numerous casts of an Ostracoid crustacean which I refer provisionally to *Cytherina*. These are the first examples of that order of crustaceans, so far as I am aware, that have been discovered in strata of the Laramie Group.

12. *Fish remains.*

A few cycloid scales were also found in these shales, which, except a few similar examples found in Bear River Valley, are the only fish remains discovered by myself in Laramie strata; but there seems to be no reason why fishes may not have existed abundantly during that period.

The absence of the *Ostrea* here is noticeable, and is probably due to the uncongeniality of habitat that was produced by the fine sediment which now constitutes the shales. *O. glabra* was found further down the valley of White River in strata fully as near the base of the group as

these shales are, and that species is therefore known to have as great a vertical range as any of the other species of the group.

The Laramie Group of this district is made up of sandstones and sandy shales, with occasional layers of clayey shales, which toward the base are reddish in color, indurated, fine-grained, and fissile. There are also several beds of coal or lignite in the group as developed in this region, one being near the horizon of the fossils of the foregoing list and another near that of the fossils collected from the upper strata of the group in Yampa Valley. Besides this, comminuted fragments of plants are very common in almost all the strata from base to top of the group, and in some of the layers they are very abundant.

In the Danforth Hills, and also extending far down White River Valley, and over to Yampa Valley, the strata of nearly the whole group have a decided reddish aspect, which often appears as if produced by heat. The fossils of the foregoing list were all collected from the reddish fissile shales before mentioned, about fifteen miles northwestward from White River Indian Agency, mostly about 400 feet above the base of the group, and I found fragments of a part of the same species three miles to the southward of that locality, some 300 feet lower in the series, or within 100 feet of the base. About 200 feet beneath these lowest Laramie fossils I obtained some characteristic fossils of the Fox Hills Group, which will be discussed on following pages. The plane of division between these two groups is of course between these two fossiliferous layers, which are only 200 feet apart. No unconformity of any of these strata could be detected, nor is there any abrupt change from the lower to the higher group; yet viewing the strata as they are abundantly exposed in the hillsides of the district, one has little difficulty in tracing a sufficiently distinct line of division by the aspect of the strata. This difference of aspect is due mainly to the greater thinness of the layers that compose the strata which are referred to the Laramie Group, and also to a perceptible difference of color.

The remaining investigations of the Laramie Group for this season, (except those of the peculiarly developed portion of the group at the western part of Green River Basin) were made near its close in the valley of Bitter Creek, in Southern Wyoming, from 100 to 125 miles northwestwardly from the Yampa and White River localities. As the faunæ of the two districts are intimately related, I shall depart from the course of my journey to discuss, in immediate connection with the foregoing, the Laramie Group and its fossils as developed in the valley of Bitter Creek, and then return to the Fox Hills Group, in the valley of White River, and follow the line of my journey to its close.

In the valley of Bitter Creek, a tributary of Green River, the whole series of Laramie strata is twice exposed, once on each side of a broad anticlinal flexure, called by Professor Powell the Aspen Mountain Uplift. Fossils were obtained from them on both sides of the fold, but they all come apparently from the upper half of the series, although they occur at several distinct fossiliferous horizons. My examinations began in the valley of Bitter Creek, just west of the village of Rock Springs, where the uppermost strata of the group occur, the dip being to the westward. I made careful examination here, as well as formerly in Yampa Valley, for a plane of demarkation between the Laramie and Wasatch Groups, but without success. I rode back and forth, on the western side of the valley, over the upturned edges of the strata between two fossiliferous horizons containing characteristic fossils of each group respectively, and I could nowhere find a plane of demarkation or any particular layers suggestive of a plane of separation between the two groups.

The uppermost fossiliferous layer of the Laramie Group, doubtless equivalent with the fossiliferous horizon both at Point of Rocks Station and in Yampa Valley, was found in the hill just west of the village of Rock Springs, where I obtained only one species, *Ostrea glabra* Meek & Hayden. The fossils of the following list were obtained at other and lower horizons in the group just east of the village:

LIST OF LARAMIE FOSSILS COLLECTED AT ROCK SPRINGS, WYOMING.

1. *Ostrea glabra* Meek & Hayden.
2. *Anomia micronema* Meek.
3. *Volsella (Brachydontes) regularis* White.
4. *Corbula undifera* Meek.
5. *Melania insculpta* Meek.

No other fossils were obtained from the Laramie strata on the west side of the Aspen Mountain Uplift, but important collections were made from them at three localities upon the east side. The first of these localities is about two miles below or west of Point of Rocks Station, where the following fossils were obtained:

LIST OF LARAMIE FOSSILS FROM BITTER CREEK VALLEY, TWO MILES WEST OF POINT OF ROCKS STATION, WYOMING.

1. *Ostrea glabra* Meek & Hayden?
2. *Anomia gryphorhynchus* Meek.
3. *Corbicula cytheriformis* Meek & Hayden.
4. *Corbula subtrigonalis* Meek & Hayden (= *C. tropidophora* Meek).
5. *Melania insculpta* Meek.
6. *Odontobasis buccinoides* White.

The exposure here is only a very limited one of a single stratum of fossiliferous rock, being the same as that from which Mr. Meek collected his type specimens of *Anomia gryphorhynchus*. The position of this fossiliferous horizon in the Laramie series is probably about the same as that just east of the village of Rock Springs, although most of the fossils are of different species.

The fossiliferous horizon at Point of Rocks station, two miles farther up the creek, holds a position several hundred feet above the one in question. Just how much higher in the series it belongs could not be accurately known, because there is an unconformity of the strata between the two horizons. This unconformity is evidently of limited extent in this district and has probably not greatly affected the aggregate thickness of the whole group. I could find no trace of it in the Laramie strata of the valleys of Yampa and White Rivers, but Professor Powell has reported it to exist elsewhere, and upon it he made the division between his Point of Rocks and Bitter Creek groups. I adopted his views in this respect in my report upon his collections, in the third chapter of his Report on the Geology of the Uinta Mountains; and also in my Paleontological Papers Nos. 2, 3, and 5 in the Bulletin of the United States Geological and Geographical Survey of the Territories. Subsequent investigations, however, show that the paleontological characteristics of the strata above and below this unconformity are too nearly identical to admit of their separation as belonging to separate epochs, even if that unconformity were general instead of local.

The fossiliferous horizon at Point of Rocks station is the uppermost one of the group that is yet known, and is essentially the same as that

at Black Buttes station, twelve miles farther up the creek, and also the same as that in the valley of the Yampa. At Point of Rocks it comprises two layers containing the fossils, separated by 50 feet of strata in which none were found. Only *Corbula subundifera* White and *Campeloma vetula* Meek & Hayden were found in the lower layer, and the remainder of the following list were obtained from the upper layer.

LIST OF LARAMIE FOSSILS COLLECTED AT POINT OF ROCKS STATION, WYOMING.

1. *Membranipora ?*
2. *Ostrea glabra* Meek & Hayden.
3. *Corbicula occidentalis* Meek & Hayden.
4. *Corbula subundifera* White.
5. *Campeloma vetula* Meek & Hayden.

The layers that have furnished the important collections of plant remains at Point of Rocks station, which have been described by Mr. Lesquereux, were found to be lower in the Laramie series than those which furnished the fossils of the foregoing list, and they are also below the unconformity that has been referred to. Proceeding up the valley of Bitter Creek the horizon of the invertebrate fossils was once or twice detected by some scattered fragments of oyster-shells, but no important collections were made until I reached Black Buttes station, some twelve miles to the southeastward. I stopped on the way at the Hallville mines where Mr. Meek had formerly obtained some Laramie fossils, but as the mines had been abandoned I was unable to make any collections. The strata of the Black Buttes locality were found to contain fossils for a considerable distance both above and below the railroad station and upon both sides of the creek, the principal locality being about a mile south of the station.

LIST OF THE LARAMIE FOSSILS COLLECTED AT BLACK BUTTES STATION, WYOMING.

1. *Anomia micronema* Meek.
2. *Anomia gryphorhynchus* Meek.
3. *Ostrea glabra* Meek & Hayden.
4. *Unio couesi* White.
5. *Unio propheticus* White.
6. *Unio aldrichi* White.
7. *Unio proavitus* White.
8. *Unio holmesianus* White.
9. *Unio endlichi* White.
10. *Unio cryptorhynchus* White.
11. *Unio brachyopisthus* White.
12. *Unio goniambonatus* White.
13. *Unio danæ* Meek & Hayden.
14. *Corbicula occidentalis* Meek & Hayden.
15. *Corbicula (Leptesthes) fracta* Meek.
16. *Corbula subtrigonalis* Meek & Hayden.
17. *Neritina volvilineata* White.
18. *Neritina (Velatella) baptista* White.
19. *Goniobasis gracilienta* Meek & Hayden.
20. *Cassiopella turricula* White.
21. *Melania wyomingensis* Meek.
22. *Viviparus plicapressus* White.

23. *Tulotoma thompsoni* White.
24. *Campeloma vetula* Meek & Hayden.
25. *Campeloma multilineata* Meek & Hayden?

NOTES ON THE LARAMIE FOSSILS OF BITTER CREEK VALLEY.

As the fossils of the different localities in Bitter Creek Valley are so closely related they will all be discussed in zoological order in the following notes instead of treating those of each locality separately.

1. *Membranipora?*

Upon many of the shells of *Ostrea glabra* Meek & Hayden (=*O. wyomingensis* Meek), which were obtained at Point of Rocks, there are small patches of an incrusting Polyzoan. None of them are quite perfectly preserved, but they are evidently the calcareous cell-bases of a species of *Membranipora* or of a closely allied genus. I have detected similar objects at no other locality of Laramie fossils except in the valley of Bear River, but there seems to be no good reason why they may not have existed with any of the many brackish-water species of that period. They are interesting as indicating the continuance of a considerable degree of saltness of the waters until near or quite the close of the Laramie period.

2. *Anomia micronema* Meek.

This species has already been discussed upon previous pages as to its geographical distribution and vertical range in the Laramie Group. A few small examples of it were found at the Black Buttes locality, and it was also found quite abundantly at the Rock Springs locality, but nowhere else in Bitter Creek Valley. At both those localities it was found in a separate layer associated only with *Ostrea glabra*. At the Rock Springs locality the examples are of good size, and many of them have a greater than the average convexity of form.

At none of the numerous localities where this species has been found, from the one reported by Dr. Hayden, two hundred miles east of Denver, to those of Bitter Creek Valley, none but upper valves have been discovered. It is very difficult to even suggest an explanation of this remarkable fact, which has before been referred to.

3. *Anomia gryphorhynchus* Meek.

The locality two miles below Point of Rocks is the only one that has furnished many examples of this species, although it has been clearly recognized at the Crow Creek locality east of the Rocky Mountains, and also at the Black Buttes and Yampa Valley localities. This shows a wide geographical distribution and a considerable vertical range of the species. As in the case of *A. micronema*, none but upper valves of this species have been found.

4. *Ostrea glabra* Meek & Hayden.

This species has already been discussed at length on former pages, and reasons given for referring these western forms to *O. glabra* Meek & Hayden rather than to regard them as a separate species under the name of *O. wyomingensis* Meek, the types of which were found at Point of Rocks. If it were not for the lately obtained proof that the Judith River, Fort Union, Colorado Lignite and Bitter Creek series all belong to one and the same period, and the discovery of intermediate forms connecting these two formerly recognized species of *Ostrea*, it is not probable that I should have ever suspected them to be distinct. The lack of intermediate

forms west of the mountains like those which were found in Eastern Colorado is suggestive that there may after all be really two species, especially so since only thin, small examples are found at the locality two miles west of Point of Rocks. In Professor Powell's Report on the Geology of the Uinta Mountains I gave the name of *O. insecuris* to these last-mentioned examples, but comparison of my types directly with those of *O. glabra* shows too little difference to be satisfactorily regarded as specific. Comparison of large collections made at the typical localities, Point of Rocks and Black Buttes Station, with the types themselves, leaves no doubt in my mind that *O. wyomingensis* Meek and *O. arcuatilis* Meek are specifically identical. It will of course be understood that I regard such forms as the types of *O. glabra* Meek & Hayden, *O. subtrigonalis* Evans & Shumard, and *O. insecuris* White as young examples of the species, and *O. wyomingensis* Meek as adult forms of the same. By these and other remarks on previous pages it will be seen that at present I recognize only one species of *Ostrea* in all the Laramie Group, unless the obscure one that is found in Bear River Valley, yet to be noticed, shall prove to be distinct from *O. glabra*.

5. *Volsella* (*Brachydontes*) *regularis* White.

A few large but imperfect examples of this species were found just east of Rock Springs, which is the only locality in Bitter Creek Valley, at which it was discovered. See further remarks under the head of notes on the Laramie fossils of Crow Creek Valley.

6. *Unio couesi* White.

This is one of nine or ten species of *Unio* that have been found associated in one and the same layer at Black Buttes Station, and also associated with *Corbicula* (*Leptesthes*) *fracta*, *Neritina volvilineata*, *Neritina* (*Velatella*) *baptista* and *Melania wyomingensis*. None of these species of *Unio* have been discovered at any other locality west of the Rocky Mountains, but two of them, *U. cryptorhynchus* White and *U. danæ* Meek & Hayden, have been somewhat satisfactorily identified with the typical forms from the Upper Missouri River region. This is the largest species of the genus that has yet been found fossil in any strata of the West. It was originally described by me under the name of *U. petrinus* in Powell's Report on the Geology of the Uinta Mountains, p. 125, together with Nos. 7 and 8 following. That name being preoccupied, it was changed to *U. couesi*, in Bull U. S. Geol. and Geog. Sur. Terr., vol. iii, p. 605.

7. *Unio propheticus* White.
8. *Unio brachiopisthus* White.

} See remarks under No. 6.

9. *Unio proavitus* White.

This species, together with Nos. 10 and 11 following, are described in Bull. U. S. Geol. Sur. Terr. vol. iii, pp. 603 and 604.

10. *Unio holmesianus* White.
11. *Unio endlichi* White.

} See remarks under No. 6.

12. *Unio aldrichi* White.

This species, together with No. 13 following, are described in Bull. U. S. Geol. Sur. Ter. vol. iv, pp. 709 and 710.

13. *Unio goniambonatus* White.

See remarks under No. 6.

14. *Unio cryptorhynchus* White.

Some imperfect examples found associated with the foregoing species appear to be specifically identical with the types of *U. cryptorhynchus*

which were collected by Prof. E. D. Cope from the Judith River beds of the Upper Missouri River region. It is described in Bull. U. S. Geol. and Geog. Sur. Terr. vol. iii, p. 600.

15. *Unio danæ* Meek & Hayden?

Several well-preserved examples were obtained with the other species of *Unio* at Black Buttes Station that have much the form of the living species *U. rectus*. They appear, however, to be too nearly related to, if not specifically identical with, *U. danæ* Meek and Hayden to warrant any other reference at present.

16. *Corbicula occidentalis* Meek & Hayden.

The possible identity of this species with the following has already been referred to, but the two forms although closely related are (when studied by numerous specimens of each form from Bitter Creek Valley) quite readily distinguishable. The two forms are also from two separate horizons, *C. occidentalis* being found only in that of Point of Rocks and Black Buttes Stations, and *C. cytheriformis* only in that of the locality two miles below Point of Rocks. *C. bannisteri* Meek, as has already been stated, is regarded as only a variety of *C. occidentalis*. This species is quite abundant in the principal oyster layer at Point of Rocks, and is similarly associated at the Yampa Valley locality. Among some collections brought by Professor Powell from Upper Kanab, Utah, are some examples that appear to belong to this species. It has not been recognized east of the Rocky Mountains in Colorado.

17. *Corbicula cytheriformis* Meek & Hayden.

Many well-preserved examples of this species were obtained at the locality two miles below Point of Rocks. They are of smaller average size than the types of the species, but they seem to be specifically identical. This species was not recognized east of the Rocky Mountains in Colorado, and only doubtfully so in the Danforth Hills, which is the only other locality at which it has been recognized west of the Rocky Mountains.

18. *Corbicula* (*Leptesthes*) *fracta* Meek.

A single layer at Black Buttes Station contains this species in great abundance, and it was here and at Hallvile, four miles distant, that Mr. Meek obtained the types of this species and of the subgenus *Leptesthes*. Its geographical distribution is about the same as that of *Melania wyomingensis*, and its vertical range apparently through the whole thickness of the Laramie Group. For further remarks on this subject see notes on the Laramie fossils of Crow Creek Valley.

19. *Corbula undifera* Meek.

The typical forms of this species have hitherto been found only at Rock Springs and in the Danforth Hills. The type collection of *C. subundifera* White was obtained at Point of Rocks station from a layer about fifty feet below the oyster horizon there, and the form was described in Professor Powell's Report on the Geology of the Uinta Mountains, p. 129. The only other known examples were brought by Professor Powell from Upper Kanab, Southern Utah, as mentioned on a previous page. The differences between these two forms are so slight that I am now disposed to regard them as only varieties of one species; but still the variation seems to be constant as found in widely separated localities, which is suggestive of a permanency that may prove to be specific.

20. *Corbula subtrigonalis* Meek & Hayden.

It has been stated on a previous page that good reasons appear to exist for regarding *C. subtrigonalis* Meek & Hayden, *C. perundata* Meek & Hayden, *C. crassatelliformis* Meek, and *C. tropidophora* Meek, as belonging to one and the same species, the difference being only varietal and probably due to local environment. Mr. Meek's types of the two last-named forms were obtained from the Bitter Creek series of Laramie strata, the former at Hallville and Black Buttes stations, and the latter at the locality two miles below Point of Rocks. The difference between these two latter forms is significant as being similar to that between *C. undifera* and *C. subundifera*, and also similar to that between other forms from different strata of the Bitter Creek series presently to be noticed.

21. *Neritina volvilineata* White.

The type specimens of this species were found at Black Buttes Station associated with *Melania wyomingensis*, *Corbicula* (*Leptesthes*) *fracta*, and seven or eight species of *Uniones*. Yampa Valley is the only other locality at which this species has been discovered. See remarks under that head on a previous page.

22. *Neritina* (*Velatella*) *baptista* White.

In Ann. Rep. U. S. Geol. and Geog. Sur. Terr. for 1872, pp. 497–499, Mr. Meek described three species of *Neritidæ* from the Cretaceous rocks at Coalville, Utah, for which he proposed the subgeneric name of *Velatella*. In their distinguishing charactistics they approach *Velates* Montfort, but the differences pointed out by Mr. Meek are doubtless of at least subgeneric value. Two of the species described by him were found in the brackish-water layers at Carleton's coal mine, which are both underlaid and overlaid there by marine strata of the Fox Hills Group; and the other was from marine Cretaceous strata of the same series a couple of miles away from the first-named locality. *N.* (*V.*) *baptista* is described in Bull. U. S. Geol. and Geog. Sur. Terr. vol. iv, p. 715, and was found in the Laramie strata at Black Buttes Station associated with the preceeding species and its brackish- and fresh-water associates there. This peculiar type has been found at no other than the Coalville and Black Buttes localities, the one in the Fox Hills Group and the other in the Laramie.

23. *Goniobasis gracilienta* Meek & Hayden.

A goodly number of examples were found at the Black Buttes locality which appear to be specifically identical with *G. gracilienta* Meek & Hayden, although they are smaller and rather more slender than the types of that species are, and also more slender than those examples are that were found in Crow Creek Valley east of the Rocky Mountains. For remarks on that species see notes on the fossils of the last-named locality.

24. *Cassiopella turricula* White.

This is the type and only species of the genus *Cassiopella* that has yet been discovered. It has been found only at the Black Buttes locality, where it is associated with *Unio*, *Corbula*, *Goniobasis*, *Campeloma*, &c. Although it is a very interesting form, being unique, it is of little value in the present discussion, which is mainly one of comparison. It is described in Powell's Report on the Geology of the Uinta Mountains, page 133, under the name of *Leioplax? turricula*, but it was made the type of *Cassiopella* in Bull. Geol. and Geog. Sur. Terr. vol. iii, p. 606.

25. *Melania wyomingensis* Meek.

This is one of the finest and most interesting species yet discovered in

the Laramie Group. Mr. Meek obtained his type specimens at the Black Buttes locality, and it has since been obtained in considerable numbers both east and west of the Rocky Mountains, in Colorado and Wyoming, but it has not yet been discovered in the Upper Missouri River region. Its wide geographical distribution; its great vertical range in the Laramie Group; its apparently true *Melanian* type and its relation to the following species from a lower horizon in the group in Bitter Creek Valley, all make it a species of unusual interest. For further remarks on it see notes on Laramie fossils from Crow Creek Valley and the Danforth Hills localities.

26. *Melania insculpta* Meek.

Mr. Meek described this species in the Ann. Report of the U. S. Geol. and Geog. Sur. Terr. for 1872, p. 515, along with *M. wyomingensis*, his types of the former having been obtained at Rock Springs, and those of the latter at Black Buttes Station. No examples of *M. insculpta* have been found elsewhere than at Rock Springs, except two or three imperfect ones at the locality two miles below Point of Rocks. It is much more nearly related to *M. wyomingensis* than would appear at first glance, because the principal difference consists in the row of prominent nodes or short spines that adorn the larger volutions of the latter; while the upper turns of the spine of each seem to be undistinguishable. This is another case of very closely related species or well-marked varieties existing the one above and the other below the line of unconformity that has been shown to exist in the Laramie strata of Bitter Creek Valley.

27. *Viviparus plicapressus* White.

The only localities at which this species has yet been discovered are those of Black Buttes Station and Yampa Valley. At the latter locality it was found associated with *Melania wyomingensis* and *Neritina volvilineata;* and at the former with *Unio*, *Corbula*, *Goniobasis*, *Cassiopella*, *Campeloma*, &c. It is described in Powell's Report on the Geology of the Uinta Mountains, p. 133. It is not yet known east of the Rocky Mountains.

28. *Tulotoma thompsoni* White.

Black Buttes Station is the first locality at which this species was discovered, and the valley of Crow Creek, east of the mountains, is the only other one at which it has been found. It occurs in considerable numbers at each of these localities, and its identity at each is beyond question. Its associates at Crow Creek are all fresh-water forms; and at Black Buttes it seems to occupy a thin layer by itself between those which contain both brackish- and fresh-water forms. See further remarks under the head of "Notes on the Laramie fossils of Crow Creek Valley."

29. *Campeloma vetula* Meek & Hayden.

Dr. Hayden first discovered this species in the Judith River beds of the Upper Missouri River region, and it is described and figured in volume IX of the United States Geological Survey of the Territories. A goodly number of examples were obtained at Black Buttes Station, where they were found associated with *Unio*, *Corbula*, *Goniobasis*, *Cassiopella*, &c. Their specific identity with *Campeloma vetula* seems to be unmistakable.

30. *Campeloma multistriata* Meek & Hayden.

Some examples found associated with the foregoing species at Black Buttes Station possess distinct revolving lines like those of *C. multistriata*, but they lack the shouldering of the distal side of the body-volution so common in that species. As they do not appear to differ materially in

general shape from *C. vetula*, they may perhaps be only a variety of that species. This is rendered probable by the fact that the revolving lines are often obsolete on *C. multistriata*, as well as other striated species.

31. *Odontobasis buccinoides* White.

This species is described in Powell's Report on the Geology of the Uinta Mountains, p. 124. With the exception of a single species found in the Danforth Hills, and doubtfully referred to this genus, only two other species of the genus are known. These are both of Cretaceous age, and are associated only with marine forms. The living affinities of the genus are also with those only of marine habitat, and it is probable that this species actually lived only with those that could endure a considerable degree of saltness of the water. It has been found only at the locality two miles west of Point of Rocks, where its associates are *Ostrea*, *Anomia*, *Corbicula*, *Corbula*, and *Melania* (*insculpta*). The specimens of the last-named species may have been drifted to their present association from a more natural habitat, but it is possible they all lived together, especially so since *M. wyomingensis* has been found at various localities associated with brackish-water forms.

Bitter Creek Valley is one of the most important districts yet known for the study of the Laramie Group; and on account of the large number of species of its fossils found there the Black Buttes locality is one of especial importance and interest. The following is a section of the strata as they appear about a mile south of the station, the point where the greater part of the fossils were obtained:

Section of Laramie Strata at Black Buttes Station.

		Feet.
1.	Thin bedded sandstones and sandy, ferruginous shales to the top of the Laramie Group	500?
2.	Sandstone, containing *Unio couesi*, *Campeloma vetula*, and *Anomia gryphorhynchus*	3
3.	Sandy shales, somewhat carbonaceous	4
4.	Shales, containing *Cassiopella turricula*, *Viviparus plicapressus*, *Goniobasis gracilienta*, *Campeloma vetula*, *Unio danæ?*, *Corbula subtrigonalis*, &c	1
5.	Bluish, clayey shale, containing fragments of *Ostrea* and *Anomia*	5
6.	Calcareous fragmentary layer, containing an abundance of *Tutoloma thompsoni*, mostly decomposed	1
7.	Calcareous and sandy fragmentary material, very fossiliferous, containing all the species of *Unio* of the foregoing list, *Corbicula* (*Leptesthes*) *fracta*, *Melania*, *wyomingensis*, *Neritina volvilineata*, *N.* (*Velatella*) *baptista*, &c	4
8.	Sandy shales, with alternating calcareous fragmentary layers	30
9.	Dark carbonaceous shales, with *Ostrea* and *Anomia*	6
10.	Common sandstones	100
11.	Sandy, grayish shales and soft sandstones	300

In the neighborhood of Black Buttes Station there are, within the limits of this section, three or four coal or carbonaceous horizons, two of which have been worked for coal. One of these appears to be represented by No. 3, and another by No. 9 of the section; but all the beds of the series exposed in this neighborhood are so extremely variable that sections taken at points not more than a quarter of a mile distant from each other would hardly be recognized as intended for the same locality, especially in its thinner members.

The beds of coal are not continuous here, as they usually are in the Carboniferous Coal-Measures; but from a good workable thickness at one point a bed will disappear entirely within half a mile. The layers containing the fossils are equally inconstant as regards their fossil contents, and a measured section half a mile away from the point where the foregoing one was measured, comprising the exact equivalents of those beds,

might be examined in vain for fossils of any kind. Yet there is no evidence that any of these layers are of truly estuary origin, or that they were formed in any other than lacustrine or interior sea waters. In other words, the variation referred to seems to have been the result of shifting conditions of limited extent in a large body of water, rather than that of the meeting of fluviatile and lacustrine or sea waters. This inconstancy of the layers composing a large part of the Laramie Group is common almost everywhere, and indicates a general prevalence of shallow water during the Laramie period. The frequent mixture in a single layer of fresh-water, brackish-water, and marine types in these and other Laramie strata is very perplexing, and will be further discussed on following pages.

The dip of all the strata at Black Buttes Station is gently to the eastward, and going in that direction a few miles one finds himself upon the strata of the Wasatch Group. I crossed and recrossed this space at different places in the neighborhood, and failed, as I had done before at other localities, to find any plane of demarkation, or any indication of a division between the Laramie and Wasatch Groups. The thickness therefore that is assigned to No. 1 of the foregoing section is only an approximate estimate. I do not doubt that there are places, even within the Green River Basin, where there is a true unconformity of strata at or about the junction of the two groups, but I have not had the good fortune to examine any such localities personally. In this statement reference is not made to the great unconformity of the Wasatch upon the Laramie at the extreme western portion of that geographical basin, or rather upon the eastern borders of the Salt Lake Basin, which will be discussed on following pages.

Within 100 feet above the base of No. 1 of the foregoing section I found fragments of bones, probably those of *Agathaumas sylvestris* Cope, which is probably the identical locality at which Professor Cope obtained his type specimens. I found no invertebrate fossils of any kind above No. 2 of the section; and it will thus be seen that vertebrate remains of Cretaceous type are found above all the invertebrate fossils of the Black Buttes locality, and that the former were obtained from the uppermost portion of the Laramie Group. Some reference to the discussions that have taken place as to the geological age of these strata will be made on a following page.

Before taking leave of the Bitter Creek series there is an interesting matter to be considered in relation to it. The existence of an unconformity of the strata of the upper part of the Laramie series upon those of the lower part, especially observable in the neighborhood of Point of Rocks, has already been noticed. As already hinted, there are some interesting differences among the fossils that respectively characterize the strata above and below the unconformity. For example, in Bitter Creek Valley the typical forms of *Corbula undifera* are not found above the unconformity, and those of *C. subundifera*, which I now regard as only a variety of the first, are not found below it. The variety of *Corbula subtrigonalis* to which Mr. Meek gave the name of *C. tropidophora* is found only below the unconformity, while that which he called *C. crassatelliformis* is found only above it. *Melania insculpta*, which seems to differ from *M. wyomingensis* only in the absence of the nodes or short spines which characterize the latter, is found only below the unconformity, while the last-named species is found only above it. Also *Corbicula cytheriformis* is found only below the unconformity, while the closely related form *C. occidentalis* is found only above it. It would be too much to assume that all the upper forms here named are the lineal

descendants of their lower representatives respectively, but the local facts are at least suggestive of some such connection. At any rate, there seems to be no reason for doubt that the change of condition consequent upon the movement that caused the unconformity brought about a corresponding change in the aqueous fauna.

Leaving the Bitter Creek district, with much that is interesting there, to be noticed in the closing discussion, I now return to the Danforth Hills, near White River, and resume my observations, in the order of my journey, where I left them to consider the Bitter Creek series.

My journey upon leaving the Danforth Hills was by way of a cañon that opens into Agency Park at a point about six miles directly south of the locality where I obtained the collection of Laramie fossils, and near the western end of the park.

In the sides of this cañon appears the junction between the Laramie and Fox Hills Groups, the character of which has already been described. Following down the drainage of the cañon into the park, we come upon the Colorado Group, and upon the banks of White River we find the strata of the Dakota Group also. No fossils were found in the latter, but fragments of *Inoceramus deformis* with *Ostra congesta* were found in the former. About a mile up from the mouth of the cañon I obtained, from a layer of the Fox Hills Group, within 100 feet of its top, the fossils of the following list. Near by, in the same cañon-side, 200 feet above the layer just mentioned (100 feet above the base of the Laramie Group), I collected fragments of some of the same species of fossils, both vegetable and invertebrate, that were found to characterize the Laramie strata in the hills five miles to the northward, which have already been discussed. The fact has already been stated, that although the plane of division between the Laramie and Fox Hills Groups in this neighborhood is quite plainly recognizable, it is marked by no unconformity, nor by any such abrupt change in the character of the deposits as would prove a break to have taken place in the continuity of sedimentation. Thus we find a purely marine condition indicated for the origin of the stratum affording the fossils of the following list, and a brackish-water condition for that of all the strata which are more than 100 or 200 feet above it, which condition continued unchanged through a deposition of strata nearly or quite 4,000 feet in thickness:

LIST OF CRETACEOUS FOSSILS FROM A CAÑON SIX MILES NORTHWEST FROM WHITE RIVER INDIAN AGENCY, NORTHWESTERN COLORADO.

1. *Inoceramus barabini* Morton.
2. *Cardium speciosum* Meek & Hayden.
3. *Mactra* (*Cymbophora*) *alta* Meek & Hayden.
4. *Anisomyon centrale* Meek.
5. *Actæon woosteri* White?
6. *Baculites ovatus* Say.

NOTES ON THE CRETACEOUS FOSSILS FROM NEAR WHITE RIVER INDIAN AGENCY.

1. *Inoceramus barabini* Morton.

Examples of this species were found to be quite abundant at some places in the fossiliferous stratum in which they were found. They seem to agree well with the typical forms of the species.

2. *Cardium speciosum* Meek & Hayden.

This species has not been found so common west of the Rocky Mountains as east of them. Besides this locality, I also found it at that of Dodds's Ranch, presently to be noticed. In these western localities it appears to possess all the characteristics of the typical examples. Its presence here, associated as it is with the next following species, indicates that the strata containing it are the uppermost of the series.

3. *Mactra* (*Cymbophora*) *alta* Meek & Hayden.

So far as I am aware, no example of this species has ever been found in any other than the uppermost strata of the Fox Hills Group. It is, therefore, valuable here as indicating the highest horizon of the group; which is also indicated by the position of the strata in relation to those of the Laramie Group. For remarks on this and the two preceding species, see foregoing pages; and for figures and descriptions, see vol. ix, U. S. Geol. Sur. Terr.

4. *Anisomyon centrale* Meek.

The examples found here seem to be referable to this species, but they might with equal propriety be referred to some one of those which Mr. Meek has described from the Upper Missouri River region, all of which are difficult of separation. *Anisomyon* appears to range higher in the Fox Hills Group west of the Rocky Mountains than east of them. I have never before found it associated with either of the two foregoing species.

5. *Actæon woosteri* White.

A single fragment was found, associated with the fossils of the foregoing list, that seems to belong to this species, which has been hitherto found only in Southern and Eastern Colorado.

6. *Baculites ovatus* Say.

It has already been shown that this species is not known to range to the top of the Fox Hills Group in the Upper Missouri River region, nor in Eastern Colorado. Here, however, it is not only found in the uppermost strata of that group, but it is associated with species that are regarded as especially characterizing its highest fossiliferous horizon.

These Danforth Hills localities are especially interesting, because they contain, in one and the same exposure of strata, fossiliferous horizons that are respectively characteristic of the Fox Hills and Laramie Groups within comparatively a few feet of each other, and with no unconformity of strata between them. It seems, therefore, conclusive that the change from a marine to a brackish condition of the waters, and the consequent total change of aqueous fauna, took place in consequence of movements that occurred elsewhere, but which were not sufficient here to break the continuousness of sedimentation.

The structural geology of this region having been reported on by me for the year 1876, all relating to it, except matters of a paleontological character, will be omitted from this report. Proceeding down the valley of White River a few comparatively unimportant collections were made on the way. The first of these was made from Wasatch strata from point to point between Piñon Ridge and Raven Park, where the upper strata of that group were found exposed in the valley of White River. The fossils collected were not abundant, and consisted of only five species, most or all of which are known to pass up into the Green River Group at other localities.

LIST OF FOSSILS OF THE WASATCH GROUP COLLECTED IN WHITE RIVER VALLEY, COLORADO.

1. *Unio shoshonensis* White.
2. *Unio washakiensis* Meek.
3. *Physa pleromatis* White.
4. *Goniobasis tenera* Hall.
5. *Viviparus paludinæformis* Hall.

NOTES ON THE WASATCH FOSSILS OF WHITE RIVER VALLEY.

1. *Unio shoshonensis* White.

This species is described in Powell's Report on the Geology of the Uinta Mountains, p. 126, the types having been collected from different portions of the Green River Group in Southern Wyoming. Not only this, but also all the other species of the foregoing list, except *Physa pleromatis*, are known to range from the Wasatch Group into, and part of them entirely through, the Green River Group.

2. *Unio washakiensis* Meek.

Mr. Meek described this species in the Ann. Rep. U. S. Geol. Sur. Terr. for 1870, p. 314. It is quite a common species in both the Wasatch and Green River Groups, but it is seldom, if ever, found well preserved. Among typical examples of this species were found some that are at least one-third larger than Mr. Meek's types. Being only in the condition of casts, their specific determination was not satisfactory, and it is possible they represent a new species.

3. *Physa pleromatis* White.

This species is described and figured in vol. iv, Expl. and Sur. West of the 100th Meridian, the types having been collected at Last Bluff, Utah. It is not an uncommon species in the Wasatch Group in Utah, Wyoming, and Colorado. An example found in White River Valley is remarkably large, fully double the size of the type, and the largest example of the genus known to me.

4. *Goniobasis tenera* Hall sp.

In Fremont's Report on Oregon and North California, 1845, Professor Hall described and figured *Cerithium tenerum* and *C. nodulosum*, both of which, without doubt, belong to the genus *Goniobasis*, and both are doubtless of the same species. *G. tenera* being the first in order of description in that report, that name is used as the proper name of the species. In Proc. Acad. Nat. Sci. Philad. 1860, Meek described a form from Wyoming under the name of *Melania simpsoni;* and in the Am. Jour. Conch. 1868, Conrad described another, from Wyoming, under the name of *G. carteri*, both of which are other synonyms of *G. tenera.* In the An. Rep. U. S. Geol. Sur. Terr. for 1870, Meek changed *G. nodulosum* Hall sp, to *G. nodulifera*, because the former name was preoccupied by Lea for a recent species. This was unnecessary, because both are other synonyms of *G. tenera.* Several distinct species of *Goniobasis* are known to exist in the Laramie Group, but so far as I am able to discern, only one species of that genus has yet been collected from either of the three great fresh water deposits of the west, namely, the Washakie, Green River, and Bridger Groups. This species is subject to great inter-specific variation, and is known to range through the greater part of the Wasatch Group; through the Green River Group; and is believed to range well up into the Bridger Group also. It has even a greater variation than is indicated by the fact that it has already received three specific names, because a variety which I collected at Tabor Mountain in Southern Wyo-

ming is more spinous and otherwise more strongly marked than any of those other forms which have received separate specific names. The examples of this species found in the valley of White River are large, some of them being more than two inches in length, and correspond with Hall's figure and description of the variety *nodulosum* more nearly than the other varieties do.

5. *Viviparus paludinæformis* Hall sp.

This species was described in the same report together with the preceding species under the name of *Turbo paludinæformis.* It is a constant associate of *Goniobasis tenera*, and at none of the very many localities where I have collected these two species I have never found either of them unaccompanied by the other. This species varies comparatively little, even in the different groups in which it has been found. Only one other species of the genus has yet been found in either the Wasatch, Green River, or Bridger Group. This is *V. wyomingensis* Meek, which has been found only in the Bridger Group. *V. paludinæformis* apparently ranges up into the lower portion of the Bridger Group.

The fossiliferous horizon that furnished the fossils of the foregoing list was also found among the upturned strata of Raven Ridge, west of Raven Park. The ridge has its southeastern end at the western side of Raven Park and its northwestern end near Section Ridge, a spur of Yampa plateau. In the upper portion of the Wasatch Group, near the northwestern end of Raven Ridge, I obtained an abundance of specimens of *Goniobasis tenera* and a few of *Viviparus paludinæformis.* Near the southeastern end of the ridge and at the same horizon I obtained a few examples of both those species together with some of *Unio washakiensis* and *U. shoshonensis.* The Green River Group is abundantly shown in this region, in all the peculiarities which characterize the group at its typical localities, and yet no distinct plane of demarkation or place of separation between it and the Wasatch Group could be anywhere recognized.

While passing down the valley of White River from Agency Park to Raven Ridge the strata of the Laramie Group came frequently under observation. They were there found to possess all their usual lithological characteristics, and also to contain the great abundance of plant remains that was observed in the Danforth Hills. The only invertebrate fossils, however, that were found in its strata in that region were occasional examples of *Ostrea glabra*, which was found to range nearly to the base of the group. Directly north of Raven Park and about midway between White River and Midland Ridge I found numerous examples of *Halysites major* Lesquereux in layers that belong either to the base of the Laramie or to the top of the Fox Hills Group. The horizon is doubtless precisely the same as that at which this fucoid occurs at the mouth of the Saint Vrain's and elsewhere in Eastern Colorado.

From a point on White River about twenty miles below Raven Park I crossed to Section Ridge over the broad bad-land district that lies to the northward. The dip of the Green River strata which border the lower portion of White River Valley is gently to the northward where I traversed them. About eight or ten miles north of White River I found them to pass beneath characteristic strata of the Bridger Group, containing fragments of mammalian and chelonian remains. These Bridger strata occupy only a very small area of surface in the immediate valley of Red Bluff Wash, and are overlaid by the strata of the Uinta Group, which occupy the greater part of the surface of this bad-land district bordering Green River Valley. They rest unconformably upon strata

of all ages in this region from those of the Colorado to the Bridger Group, inclusive. As to its unconformity upon the Bridger strata, however, my observations south of the Uinta Mountains alone would not prove, but I found such unconformity a few years ago in the valley of Snake River, north of Junction Mountain.

Leaving the region of the White and Yampa Rivers I crossed Green River by a ford a few miles below Split Mountain and continued my journey westward after making some observations from that mountain to add to my report for the year 1876. After crossing Green River I spent some time in examining the geology of the district on the west side adjacent to the southern base of the Uinta Mountains, especially in the valleys of Brush Creek and Ashley's Fork. In this district, as well as in that which lies immediately upon the other side of Green River, I made some observations that have a most important bearing upon the proper correlation of the different groups of strata which geologists have recognized, but more especially those of Cretaceous age. In a large part of Colorado, Wyoming, and Utah the two Cretaceous groups, which in the classification modified from that which was originally adopted by Hayden and Meek for the Upper Missouri River region are designated as the Colorado and Fox Hills Groups, have been found so constant in their general lithological characteristics that field geologists have usually made these the basis of their classification of the strata, often ignoring the paleontological features entirely. My own investigations have led me to the conclusion that the paleontological characteristics of these groups are far more constant and reliable than the lithological, and this fact is especially exemplified in the district in question. Generally the plane upon which the Colorado and Fox Hills Groups are separated is marked by a more or less sudden change from a shaly or uncompacted sandy material below to ordinary stratified sandstone above. A large part of the Colorado Group, especially toward its base, is also usually made up of bluish clayey and sandy shales, with usually a horizon of bluish fissile shales at or very near the base of the group. Often, however, the lithological change from the Colorado to the Fox Hills Group is very obscure, the sandy shales of the lower group extending far up into the upper one.

In the district adjacent to Green River, at the southern base of the Uinta Mountains, more than half the thickness of the Fox Hills Group is inseparable from the Colorado Group by lithological characters, and their separation is thus practicable only by means of their respectively characteristic fossils. It is true that the relative thickness of these two groups varies very considerably in different districts, and this fact is never more plainly or truthfully shown by lithological than by paleontological features. In short there is, as a rule, in all the great western region, a distinctly recognizable paleontological horizon separating the two groups in question, irrespective of lithological variation, above and below which certain species respectively do not pass. For example, on both sides of the Rocky Mountains I have found *Inoceramus deformis* Meek, *I. problematicus* Schlotheim, and *Ostrea congesta* Conrad quite common if not abundant in the Colorado Group, while none of the Cretaceous species of any of the foregoing lists in this report have been found in that group, but all belong above it.*

* In my report upon the invertebrate fossils of Professor Powell's collections, in chapter III of his Geology of the Uinta Mountains, a considerable number of the Cretaceous species there discussed are referred to the Colorado Group (= Sulphur Creek Group of Powell), which I have now no doubt properly belong to the Fox Hills Group (= Salt Wells Group of Powell). The error made by the collectors, of referring the fossils to wrong groups, no doubt occurred in consequence of the lithological changes that have taken place in their strata, which has just been explained.

In the valley of Brush Creek I observed several more or less massive layers of sandstone distributed in the softer layers of the Colorado Group, the like of which I have not seen elsewhere in that group. Just north of Dodds's Ranch, in the valley of Ashley's Fork, a high hogback of sandstone rises up toward the flank of the mountains from the valley-plain of that stream. As one approaches it by going up the valley it has the appearance of the usual hogback of the Dakota Group, which appears almost everywhere at the flanks of the mountains, especially as the plain is known to be in part, and so far as the lithological characters of the strata can be observed beneath the surface *débris* it appears to be wholly, occupied by the strata of the Colorado Group. In fact, however, as proved by the fossils, a large part of the valley-plain is occupied by strata of the Fox Hills Group which are as soft and easily eroded as those of the Colorado Group are; and the hogback referred to constitutes the lower portion of the former group. From the strata of this hogback I collected the following fossils:

LIST OF CRETACEOUS FOSSILS AT DODDS'S RANCH ON ASHLEY'S FORK, UTAH.

1. *Inoceramus howelli* White.
2. *Cardium speciosum* Meek & Hayden ?
3. *Mactra* (*Cymbophora*) *warrenana* Meek & Hayden.
4. *Anchura* ——— ?

NOTES ON THE CRETACEOUS FOSSILS FROM ASHLEY'S FORK.

1. *Inoceramus howelli* White.

This species was originally discovered by Mr. E. E. Howell in Southern Utah, and was described by me in Powell's Report on the Geology of the Uinta Mountains, p. 114, where it was referred to a much lower horizon than it is now believed to occupy. It is redescribed and illustrated in another part of this volume.

2. *Cardium speciosum* Meek & Hayden.

Some casts of a *Cardium* in soft sandstone were found among the other specimens that seemed to belong to this species, but they are too imperfect to allow of satisfactory determination. If they really belong to this species it has here as low a range in the Fox Hills Group as it was found to have in Eastern Colorado, which, however, is not improbable.

3. *Mactra* (*Cymbophora*) *warrenana* Meek & Hayden.

Although the examples found here are in the form of casts, their identity with this species seems hardly questionable. For further remarks on this and the next preceding species, see notes on the fossils of the Fox Hills Group in Colorado, east of the Rocky Mountains.

4. *Anchura* ——— ?

Some casts only of this species were found, and they are too imperfect for specific determination. They probably belong to *A. fusiformis* Meek.

These fossils, although imperfect, are too clearly characteristic of the Fox Hills Group to admit of doubt as to the age of the strata containing them. To the north of the hogback, composed of these strata, those of the Colorado and Dakota Groups are seen to rise successively, and to rest in order upon the Jura-Trias. Both the Colorado and Dakota Groups, especially the former, are here of much less than their usual thickness,

but they are unmistakable in their lithological characteristics, and yet the latter does not here form a hogback as it usually does elsewhere.

Proceeding westward from Ashley's Fork my journey, after the first three or four miles, was over the Uinta Group until we reached Lake Fork. This group is much more extensively developed in this region than I have anywhere seen it before. It is many hundred feet in thickness, and it is quite as regularly stratified as any of the other fresh water Tertiary deposits of the West. In some places, as for example, in the vicinity of Green River, south of the Uinta Mountains, it is largely composed of soft, bad-land sandstones, having a general reddish color. But further westward it assumes a somewhat darker hue and character of quite regularly bedded sandstones, some of which are soft, but many of the strata are firm and even massive. At Wonsitz Ridge, four miles west of Dodds's Ranch, it rests unconformably upon the Laramie Group, and at Lake Fork on the Uinta and Salt Lake trail, some forty miles further west, it is found to rest upon the Bridger Group, as it was shown to do near White River, in my report for 1876.

No fossils of any kind were found by myself in the Unita Group this year, but in 1875, I obtained a *Physa* from it in the valley of Snake River, a few miles above Junction Mountain. The Uinta Group, as already shown, is regarded as equivalent with the Brown's Park Group of Powell; and it is probably also equivalent with the Lake Beds of Middle Park.

Three or four hundred feet in thickness of the strata of the Bridger Group are exposed in the valley side of Lake Fork, which have there all the peculiar lithological characteristics which they possess at the typical localities north of the Uinta Mountains, even including the various tints of coloration and the style of weathering of the bad-land sandstones of which the formation is largely composed. From these strata I made a very good collection of vertebrate fossils, consisting of Ganoid, Chelonian and Mammalian remains, but the only invertebrate form I discovered was the well known *Planorbis Utahensis* Meek (= *P. spectabilis* Meek.)

Following the trail, the course of which lies south of the wagon-road, to the east fork of the Duchesne, I found near the crossing some limited exposures of Bridger strata in its valley side, with those of the Uinta Group resting upon them, but I obtained no fossils there. Still following the obscure trail before mentioned, our journey from the east fork of the Duchesne to the main stream was over sandy barrens with here and there an exposure of sandstone. Upon reaching the latter stream I found it to run in a cañon or deep monoclinal valley excavated out of the Green River Group. The dip of these strata at the valley where I examined it is three or four degrees to the northward or northeastward, but as they are seen in the high hills south of the valley the dip seems to be considerably more there. This dip seems to be part of a broad accessory fold, subordinate to the Uinta Mountain uplift, by which these Green River strata have risen from beneath those of the Bridger Group that were seen on Lake Fork and the east fork of the Duchesne. No fossils were found in these Green River strata although diligent search was made, but the lithological characteristics are the same as they are at the typical localities north of the Uinta Mountains, the upper and lower divisions of the group being plainly recognizable. The thickness of the group as seen in this region is estimated at about 1,000 feet, but as the base was not visible where the upper division was observed, the entire thickness of the group here is probably equal to that which it attains at the typical localities. The cañon of the Duchesne, where I observed it, has high precipitous sides, and is in all respects like that

of the lower portion of White River, which is cut through the same formation.

Continuing my journey I proceeded up the north valley side of the Duchesne to the first creek that comes into it from the northward, and then up the valley of that creek to the wagon-road. None but Green River strata were seen on the way until we reached a point two or three miles south of the wagon-road, where strata that appear to be the top of the Wasatch Group were seen. At and in the vicinity of the point where the wagon-road crosses the creek the Uinta Group is seen to rest unconformably upon the Green River Group, the latter having been somewhat tilted and in some places much eroded before the deposition of the latter.

After leaving the valley of the Duchesne only a few important observations were made concerning the structural geology of the region traversed between there and Salt Lake, and no fossils were obtained from any of the strata over which we passed. All along the southern flank of the Uinta Mountains drift phenomena were observed, similar to those already noticed as observable along the eastern flank of the Rocky Mountains and in Middle Park; and also similar to those at the western base of the Rocky Mountains, which are discussed at some length in my report for 1876. The bowlders and pebbles composing the drift found along the southern flank of the Uinta Mountains is composed entirely of the rocks that make up the bulk of those mountains. There being no granite in that range, of course none is found in the drift along its flanks, wherein it differs materially from that which is distributed along both the eastern and western flanks of the Rocky Mountains, which are largely composed of granite. The drift is found almost everywhere distributed upon the surface, upon the uplands and valleys alike. In some places it is abundant, and in others almost wanting. The terraces are all more or less strewn with it, especially their abrupt sides. The beds of the streams are often so thickly covered with its bowlders as to make crossing by our animals both difficult and dangerous.

Some of the terraces along the flanks of the Uinta Mountains are quite conspicuous objects, their upper surfaces having a very gentle slope away from the foothills. The upper, flat, gently sloping surface is apparently due to erosion and not to aqueous deposition, because the deposit of gravel and bowlders upon it is generally, if not always, thin, while similar surfaces are produced indiscriminately upon the strata of the Colorado to the Uinta Groups inclusive. Moreover the surfaces of these terraces have a general correspondence with each other, while the strata out of which they are carved are tilted at various angles.

Leaving our camp at the wagon-road crossing of the creek before referred to, our way westward was along the line of strike of the Uinta Group, the dip being gently to the southward. Not far to the southward a line of hills was seen, parallel with our course, which are doubtless mainly composed of strata of the Green River Group; but I lost sight of that formation after crossing Red Creek. After crossing this creek we came upon strata that are doubtless of Cretaceous age, but these were soon passed, and none but Uinta strata were seen on our way until we reached the head of Strawberry Valley. From this valley our way was again over strata of the Uinta Group to Provo Valley, by way of Daniel's Cañon. This cañon is a long, deep gorge between high hills, which are, according to King, composed of Uinta strata. They, however, differ considerably in lithological character from any of those of that formation which I have hitherto observed. The rock is of a slightly

yellowish-gray color, and although its stratification is regular, it seems to have undergone some degree of metamorphism.

From Provo Valley our journey was by the wagon-road to Salt Lake City. At the museum in the city Mr. Barfoot showed me some fossils that had been collected at different places in the Territory, among which I recognized some of the species, specimens of which were brought from Upper Kanab, Southern Utah, by Professor Powell, whence these also are reported to have come. After renewing my outfit at Salt Lake City I turned eastward, going by way of Parley's Park, to Coalville, on Weber River, where a large series of fossiliferous Cretaceous strata is exposed.

In the An. Rep. U. S. Geol. Sur. Terr. for 1872, p. 439, Mr. Meek gives, as the result of his investigations in Weber Valley, a detailed section of the strata exposed there, from the vicinity of Coalville to Echo Cañon. This section was found to represent, with sufficient accuracy, the Cretaceous strata of that vicinity, except that there seems to be in it, near the southeastern end, some duplication of strata, doubtless caused by the presence of a fault there. This, however, does not seriously impair the usefulness of the section. About 3,000 feet in thickness of these strata are fossiliferous, many of them profusely so. The following list comprises only those that have been found within the compass of this section, in the neighborhood of Coalville.

The greater part of the species of the following list were published by the late Mr. Meek in the Am. Rep. U. S. Geol. Sur. Terr. for 1872, and vol. iv U. S. Geol. Sur. 40th Parallel. Other publications of a part of them were made by myself in vol. iv U. S. Sur. & Expl. West of 100th Meridian, Powell's Report on Geol. Uinta Mts., and in another part of the present volume.

LIST OF FOSSILS FROM THE CRETACEOUS SERIES AT COALVILLE, UTAH.

1. *Ostrea solenicus* Meek.
2. *Ostrea coalvillensis* Meek.*
3. *Ostrea congesta* Conrad?
4. *Ostrea* (*Alectryonia*) *sannionis* White.†
5. *Gryphæa* ———?
6. *Anomia* ———?
7. *Pteria* (*Pseudoptera*) *rhytophora* Meek.†
8. *Pteria* (*Pseudoptera*) *propleura* Meek.
9. *Pteria gastrodes* Meek.†
10. *Inoceramus problematicus* Schlotheim.‡
11. *Inoceramus erectus* Meek.*
12. *Inoceramus* ———?
13. *Pinna* ———?
14. *Volsella* (*Brachydontes*) *multilinigera* Meek.
15. *Barbatia coalvillensis* White.†
16. *Macrodon* ———?
17. *Unio* ———?
18. *Lucina* ———?
19. *Cardium curtum* Meek & Hayden.*
20. *Cardium subcurtum* Meek.*
21. *Cyrena carletoni* Meek.
22. *Cyprimeria? subalata* Meek.*

---

*Figured in vol. iv U. S. Geol. Sur. 40th Parallel. (King.)

†Figured in another part of this volume.

‡Figured in vol. iv Expl. & Sur. West of 40th Meredian (Wheeler). The other species not yet figured, but they are all described or noticed in An. Rep. U. S. Geol. Sur. Terr. for 1872.

23. *Tellina? isonema* Meek.*
24. *Tellina? modesta* Meek.*
25. *Tellina (Arcopagia) utahensis* Meek.*
26. *Corbula nematophora* Meek.†‡
27. *Corbula dubiosa* White.*
28. *Martesia* ———?
29. *Melampus antiquus* Meek.
30. *Physa carletoni* Meek.†
31. *Physa* ———?†
32. *Neritina bannisteri* Meek.
33. *Neritina pisum* Meek.†
34. *Neritina pisiformis* Meek.
35. *Neritina (Velatella) bellatula* Meek.
36. *Neritina (Velatella) carditoides* Meek.
37. *Neritina (Velatella) patelliformis* Meek.†
38. *Neritina (Velatella) patelliformis* var. *weberensis* White.†
39. *Euspira coalvillensis* White.†
40. *Gyrodes depressa* Meek.*
41. *Anchura fusiformis* Meek.*
42. *Turritella coalvillensis* Meek.†
43. *Turritella spironema* Meek.
44. *Turritella (Aclis?) micronema* Meek.†
45. *Turbonilla (Chemnitzia?) coalvillensis* Meek.†
46. *Eulimella? inconspicua* Meek.
47. *Eulimella? chrysalis* Meek.
48. *Eulimella? funicula* Meek.†
49. *Valvata nana* Meek.
50. *Fusus (Neptunea?) gabbi* Meek.†
51. *Fusus (Neptunea?) utahensis* Meek.
52. *Admetopsis rhomboides* Meek.†
53. *Admetopsis gregaria* Meek.‡
54. *Admetopsis subfusiformis* Meek.†
55. *Baculites ovatus* Say?*‡

NOTES ON THE CRETACEOUS FOSSILS OF COALVILLE, UTAH.

1. *Ostrea soleniscus* Meek.

This remarkable oyster ranges through something more than the upper half of the fossiliferous series that is exposed in the vicinity of Coalville. So far as I am aware it has been found only in the region bordering the eastern flank of the Wasatch Mountains.

2. *Ostrea coalvillensis* Meek.

This species is very much like the forms of *O. glabra* which are found at Point of Rocks Station and elsewhere in the Laramie Group, to which Mr. Meek gave the name of *O. wyomingensis*. It is assumed to be of a different species because of its known difference of geological position, but comparatively little is known concerning it, as only a few examples have been found.

3. *Ostrea congesta* Conrad?

Numerous examples of a small oyster were found attached to the large

*Figured in vol. iv U. S. Geol. Sur. 40th Parallel. (King.)
†Figured in another part of this volume.
‡Figured in vol. iv Expl. & Sur. West of 100th Meridian (Wheeler). The other species not yet figured, but they are all described or noticed in An. Rep. U. S. Geol. Sur. Terr. for 1872.

examples of *Inoceramus erectus* Meek, which were obtained from No. 24 of Mr. Meek's section, at the upper part of the fossiliferous series. It is difficult if not impossible to say how it differs from *O. congesta* Conrad; and its identity with that species is still further suggested by the similarity if not identity of *I. erectus* with *I. deformis* Meek of the Colorado Group, which is usually found to have lived commensally with *O. congesta*, as the *Ostrea* in question is seen to have done with *I. erectus*. It was for these reasons and for the want of access to types or illustrations that I referred this *Ostrea* and its commensal *Inoceramus* to *O. congesta* and *I. deformis* respectively, in Powell's Report on the Geology of the Uinta Mountains, p. 99.

4. *Ostrea* (*Alectryonia*) *sannionis* White.

This well-characterized species has been found only at Coalville, and only in the strata representing the space between Nos. 18 and 19 of Mr. Meek's section.

5. *Gryphæa* ——— ?

Only a couple of imperfect examples of this species were found, but it seems to be properly a *Gryphea*. If so, it is interesting as occurring at a higher horizon than usual in the Cretaceous series of the West. It occurs in No. 11 of Mr. Meek's section, with many other species.

6. *Anomia* ——— ?

Some fragments of an *Anomia* were found associated with the last-named species, and Mr. Meek also mentions the occurrence of one in No. 17 of his section, where it is associated with brackish- and fresh-water forms, intermixed with some marine forms.

7, 8, and 9.

These three species of *Pteria* are from the second ridge represented in Mr. Meek's section; and, so far as I am aware, neither of them have been found elsewhere.

10. *Inoceramus problematicus* Schlotheim.

Meek reports this species from No. 7 of his section, near the village. I found the same at Old Bear River City, thirty-five miles to the north-eastward, associated with species that occur in the second ridge at Coalville, the strata of which are considerably higher in the series than those from which Mr. Meek obtained his specimens. The former horizon is certainly within the limits of the Fox Hills Group, while the latter possibly falls within those of the Colorado Group.

11. *Inoceramus erectus* Meek.

It is this species that has already been referred to under the head of No. 3, as differing but little from *I. deformis*. In the classification adopted in Powell's Report on the Geology of the Uinta Mountains, I referred the strata containing this species to the base of the Laramie Group (=Point of Rocks Group of Professor Powell). At that time it was not uncommon for different geologists to include some of the uppermost marine Cretaceous strata in the Laramie Group. Now, however, I never intentionally include any truly marine strata in that group.

12. *Inoceramus* ——— ?

See remarks under No. 29.

13. *Pinna* ——— ?

Known only by fragments discovered by Mr. Meek.

14. *Volsella (Brachydontes) multilinigera* Meek.

This species was found in the sandstones of the first ridge at Coalville. I have also found examples, probably of the same species, in apparently equivalent strata, in the valley of Bear River, some thirty-five miles to the northeastward of Coalville.

15. *Barbatia coalvillensis*, White.

A considerable number of examples of this species were also found in the sandstones of the first ridge shown in Mr. Meek's section. It seems never to have been discovered elsewhere.

16. *Macrodon* ——— ?

The examples referred by Mr. Meek to *Macrodon* have never been seen by me. An imperfect example found by me, and apparently referable to this genus, indicates a rather large elongate species.

17. *Unio* ——— ?

See remarks under head of No. 29.

18. *Lucina* ——— ?

The few examples found were obtained from No. 3 of Meek's section. They seem to indicate a species closely allied to, if not identical with, *L. subundata* Hall & Meek.

19. *Cardium curtum* Meek & Hayden.

The proper horizon of the types of this species, which were obtained by Dr. Hayden on the Gros Ventres River, Wyoming, seems not to have been ascertained. It is therefore of no present value for the purpose of correlating those strata with those which contain this species at Coalville.

20. *Cardium subcurtum* Meek.

Besides the specimens obtained from No. 3, of Meek's section, I obtained others from some of the sandstones of the third ridge, which is much higher in that series. I also obtained some examples of it near Old Bear River City, which were associated with forms which indicate that the strata there belong to the Fox Hills Group.

21. *Cyrena carletoni* Meek.

The differences between the recognized genera *Cyrena* and *Corbicula* are so slight as to be of doubtful generic importance as regards fossil shells. I am not acquainted with any species from the Cretaceous strata of the West, except the one in question, that is referable to either of these generic forms, the examples of which have the hinge so perfectly preserved as to show the crenulations of the lateral teeth if they had ever existed. I have, therefore, referred all such to *Cyrena*, although in outward form they closely resemble some of those Laramie shells that I refer to *Corbicula*. This species, however, seems to have been entirely without crenulations of the lateral teeth, and Mr. Meek has no doubt correctly referred it to *Cyrena*. As to its associates, see remarks under No. 29.

22. *Cyprimeria ? subalata* Meek.

The examples of this and the three following species collected by me afford no further information concerning their characteristics than is recorded by Mr. Meek in vol. iv., U. S. Geol. Sur. 40th Parallel.

23. *Tellina ? isonema* Meek.

See remarks under No. 22.

24. *Tellina? modesta* Meek.

See remarks under No. 22.

25. *Tellina (Areopagia) utahensis* Meek.

See remarks under No. 22.

26. *Corbula nematophora* Meek.

Meek reports the type specimens of this species from Southern Utah. I figured an example from that region in vol. iv, U. S. Expl. and Sur. West of the 100th Meridian, which is probably of this species. The examples that I have referred to at Coalville were found associated with true marine, and not brackish-water, forms; as is also the following species. A figure of Mr. Meek's type is also given in another part of this volume.

27. *Corbula dubiosa* White.

Found also in the valleys of Bear River and Sulphur Creek. See notes on Cretaceous fossils of Bear River Valley.

28. *Martesia* ——— ?

Too imperfect for specific determination.

29. *Melampus antiquus* Meek.

In No. 16 of Mr. Meek's section, which he found exposed in Carleton's coal-mine about two miles southwestward from Coalville, he discovered a very interesting group of fossils, being Nos. 12, 17, 21, 29, 30, 32, 35, 36, 46, 47, and 49 of the foregoing list. Soon after his visit there the mine was abandoned and the fallen *débris* has so obscured the strata that no further collections from them have ever been made. Neither has any discovery of this deposit ever been made in the neighborhood or elsewhere, although one or two of the species have been doubtfully identified from Cretaceous strata elsewhere in Utah. Two of these eleven species of mollusks, Nos. 29 and 30, are palustral or littoral pulmonates; two, Nos. 17 and 49, are fresh-water branchifers; four, Nos. 21, 32, 35, and 36 are brackish-water forms, and the remaining three species, Nos. 12, 46, and 47, may be regarded as marine forms. To the latter may be added a *Cardium*, mentioned by Mr. Meek, but not enumerated in the foregoing list; and to either the brackish or marine forms may be added the *Anomia*, also mentioned by Mr. Meek as occurring with the others. This last-named species may be identical with the one found by myself in the sandstones of the second ridge and mentioned under the head of No. 6; but it is probably not the same.

This mixture of palustral, fresh- and brackish-water and marine mollusks may be taken to indicate an estuary origin of the strata containing them, although a somewhat similar admixture is found in a large part of the Laramie Group, extending over an area so wide as to make it certain that these deposits at least were made in a large, brackish-water sea. However, the evidently limited extent of this Coalville deposit, and the presence in it of so large a proportion of marine forms, may be regarded as almost certainly indicating its true estuary origin. This view is also supported by the evidence that a western shore-line to the Cretaceous sea existed not far distant from this locality. The *Physa*, No. 31 of the list, was found among the marine forms of the sandstones of the second ridge of Mr. Meek's section. This also indicates a then neighboring shore-line, but not necessarily an estuary; but the presence of brackish- and fresh-water branchiferous mollusks, as in No. 16 of that section, seems to plainly indicate an estuary origin of the strata containing them. These last-named mollusks, as well as their pulmonate associates, are

remarkably modern in type, and, seen separately, and without any knowledge to the contrary, no paleontologist would be warranted in referring them to an earlier period than the Tertiary.

The evidence of their Cretaceous age, however, is unquestionable, there being more than 1,000 feet in thickness of marine Cretaceous strata resting upon them; and more than an equal thickness of Cretaceous strata lies beneath them.

30. *Physa carletoni* Meek.

The figure of this species in another part of this volume shows plainly its modern type. For further remarks concerning it and its associates, see No. 29.

31. *Physa* ——— ?

This is possibly identical with *P. carletoni*. See a figure of it in another part of this volume; and also remarks under No. 29.

32. *Neritina bannisteri* Meek.

This is apparently a typical *Neritina*. See under No. 29 for general remarks upon its associates.

33. *Neritina pisum* Meek.

This is very like the next following species, but it is probably distinct. It is from a calcareous sandstone layer in the first ridge of Mr. Meek's section, associated with Nos. 34, 37, 38, and other species. Although it is of the same type as No. 32, its associates are all marine forms.

34. *Neritina pisiformis* Meek.

See remarks under No. 33.

35. *Neritina* (*Velatella*) *bellatula* Meek.

Mr. Meek discovered this species together with No. 36 in stratum No. 16 of his section at Coalville, associated with other brackish- and fresh-water forms. See remarks under No. 29. Together with Nos. 36, 37, and 38, it belongs to a section of the genus *Neritina*, to which Mr. Meek gave the subgeneric name of *Velatella*. Some of the associates of Nos. 35 and 36 are both brackish- and fresh-water forms, but those of Nos. 37 and 38 are all marine forms. The only other known species of this subgenus is *N.* (*V.*) *baptista* White, from the Laramie strata at Black Buttes Station, where its associates are both fresh- and brackish-water forms. In vol. iv, Expl. & Sur. West of the 100th Merid., I described and figured a form from Cretaceous rocks of Utah, which I referred to *N.* (*V.*) *carditoides* Meek, but which possibly belongs to another, but closely allied, species. Its associates there are understood to be marine forms only.

36. *Neritina* (*Velatella*) *carditoides* Meek.

See remarks under Nos. 29 and 35.

37. *Neritina* (*Velatella*) *patelliformis* Meek.

See remarks under Nos. 33 and 35.

38. *Neritina* (*Velatella*) *patelliformis* var. *weberensis* White.

See figures and description in another part of this volume.

39. *Euspira coalvillensis* White.

Found only at Coalville and in the first ridge of Mr. Meek's section.

40. *Gyrodes depressa* Meek.

This well-marked species has been found only in the form of casts, and, so far as I am aware, only from the sandstones of the second ridge of Mr. Meek's section.

41. *Anchura fusiformis* Meek.

This species was found associated with No. 39, at Coalville; and also in the Cretaceous sandstones at Old Bear River City, some thirty-five miles to the northeastward, where it is associated with *Inoceramus problematicus* &c.

42. *Turritella coalvillensis* Meek.

This, together with Nos. 33, 34, 36, 43, 44, 45, 48, and other species, was found in a calcareous sandstone layer in the first ridge of Mr. Meek's section at Coalville. It has also been found in Southern Utah.

43. *Turritella spironema* Meek.

See remarks under No. 42.

44. *Turritella (Aclis ?) micronema* Meek.

See remarks under No. 42.

45. *Turbonilla (Chemnitzia ?) coalvillensis* Meek.

This form is much like those in the Laramie beds of Bear River Valley which Mr. Meek and myself have referred to *Goniobasis*. None of the Coalville specimens are entirely perfect, but, so far as I can see, their marine associates only, suggest the impropriety of classifying them generically with the Laramie fossils just mentioned.

46. *Eulimella ? inconspicua* Meek.

This, together with No. 35 and other species, was found by Mr. Meek in stratum No. 16 of his section at Coalville, associated with brackish and fresh water forms. See remarks under No. 29.

47. *Eulimella ? chrysalis* Meek.

See remarks under Nos. 29 and 45.

48. *Eulimella ? funicula* Meek.

This species, unlike the two next preceding ones, which have been referred to the same genus, has marine associates only, having been found at Coalville only in a layer of calcareous sandstone in the first ridge of Mr. Meek's section. I described and figured a form from the North Fork of Virgin River, Utah, in vol. iv Expl. & Sur. West of the 100th Merid., and referred it to this species, with which it is probably identical. It was there associated with a form which I referred to *Admetopsis gregaria* Meek, and the two species are also found associated together at Coalville.

49. *Valvata nana* Meek.

This little shell was discovered by Mr. Meek in stratum No. 16 of his Coalville section. See remarks under No. 29.

50. *Fusus (Neptunea ?) gabbi* Meek.

This and the following species were found in the sandstones of the second ridge of Mr. Meek's section, and, so far as I am aware, they have never been recognized at any other locality.

51. *Fusus (Neptunea) utahensis* Meek.

See remarks under No. 49.

52. *Admetopsis rhomboides* Meek.

This form and No. 53 are associated together at Coalville, and I believe them to be specifically identical.

53. *Admetopsis gregaria* Meek.

See remarks under Nos. 48 and 52.

54. *Admetopsis subfusiformis* Meek.

This form is figured in another part of this volume from a drawing by Mr. Meek. I have some doubts as to its generic relation with Nos. 52 and 53.

55. *Baculites ovatus* Say?

The only example of any Cephalopod that has been discovered in the whole Cretaceous series at Coalville is a fragment of a small *Baculites* that seems to belong to *B. ovatus* Say. It was found in thin-bedded sandstone immediately overlying the strata from which Mr. Meek obtained the estuary forms that are mentioned under No. 29.

The series of strata exposed at and in the neighborhood of Coalville, as represented by its invertebrate fauna, is a remarkable one in several respects. There can be no doubt of the Cretaceous age of that whole series of strata, together with its fauna, as shown in the foregoing list of fossils; but yet, out of the fifty-five species there enumerated, only seven, namely, Nos. 5, 10, 11, 12, 40, 41, and 55, indicate the Cretaceous age of the strata, or that they belong to an earlier period than the Tertiary. Out of these fifty-five species also only four of them, namely, Nos. 3, 10, 19, and 55, have been found outside of the region adjacent to the east flank of the Wasatch Mountains and extending southward to Northern Arizona, and the identity of Nos. 3 and 54 is somewhat doubtful. Furthermore, about half of these species have hitherto been found only at and in the immediate neighborhood of Coalville, although they perhaps exist in the equivalent strata of the region that has just been referred to.

The absence from this series of Cretaceous strata at Coalville of such species as characterize the respective Cretaceous groups which have been established makes it impracticable to refer them to any one or more of those groups with certainty. Moreover, although the aggregate thickness of the strata there is greater than we should expect to find any one of those groups to possess the series seems to be a perfectly unbroken one, both stratigraphically and paleontologically. I think there is no reason for doubt that the greater part of the series at least is referable to the Fox Hills Group as it is developed and understood in Colorado and adjacent parts of Utah and Wyoming. The possibility that the lower portion of the series may be referable to the upper portion of the Colorado Group is suggested only by the greater thickness of the series than the Fox Hills Group usually attains, and the presence in those lowest strata of the Coalville section of *Inoceramus problematicus*. On the other hand this species has been found at Old Bear River City associated with forms that occur in the top of the second ridge at Coalville, the strata of which evidently belong to the Fox Hills Group. The real relations of these Coalville strata and their equivalents will doubtless be ascertained by tracing and studying the Cretaceous strata northwardly to the Missouri and Yellowstone Rivers.

These Coalville deposits were probably made in comparatively shallow waters; yet the lithological evidence of it is no greater than that presented by those widespread Cretaceous strata which contain the more common and well-known marine forms. At least, the character of their invertebrate fauna seems to have been greatly modified by the proximity of a then existing western shore to the Cretaceous sea. This view is supported by the presence of palustral, littoral, and estuary forms in some of the strata of the series, but the modification referred to, while doubtless due remotely to the same cause, is separate from such local conditions as gave those estuary mollusks their congenial habitats with-

out modifying their types, and affected all or nearly all the marine species also.

A marked contrast between the invertebrate fauna of the Coalville series and that of the whole Upper Missouri River series is shown in the almost entire absence of Cephalopods from the former, while the profusion and great variety of such forms constitutes a marked faunal feature of the latter. It is hardly to be expected that the equivalents of those Coalville strata, even in that immediate region, will be found to be quite so deficient as the present collections indicate, but a comparative paucity of them there is doubtless the rule. There is also a considerable contrast between the Cretaceous invertebrate fauna of Texas, and the territories adjacent, and that of the Upper Missouri River region, but with which that of the Coalville region has no greater affinity than with the former.

The contrast between the invertebrate Cretaceous fauna of the Coalville region and that of the Upper Missouri River region, together with its representatives in Colorado and Wyoming, has a parallel in the difference between the invertebrate fauna of the Laramie Group as represented in the valley of Bear River and that of the same group in those other regions which have been already discussed in this report; and the contrast in both cases is probably due to similar causes.

From the valley of the Weber I proceeded northward to that of Bear River, for the purpose of examining the Laramie strata there. The strata of this group have been much displaced in the region bordering the western side of Green River Basin, and the areas of surface upon which they are exposed are few and small compared with those more eastern regions of the Laramie Group which have already been noticed. This displacement of the Laramie strata has caused them to be unconformable with the Wasatch beds that rest upon them, the degree of unconformity being great in some places and only slight in others. This condition of the strata will be considered on a subsequent page, in connection with the apparently uninterrupted deposition of both the Laramie and Wasatch Groups farther eastward. The only localities of Laramie strata which I visited in this region are in two neighborhoods a few miles apart, in the valley of Bear River. The principal of these localities are in the neighborhood of the crossing of the Union Pacific Railroad, near Mellis Station on that railroad, and also near the mouth of Sulphur Creek and some eight or ten miles southeastward from Evanston, Wyo. The Laramie strata exposed in this neighborhood are those which are represented by Mr. Meek in No. 28 of his section of the rocks of that vicinity, as shown on page 451, An. Rep. U. S. Geol. Sur. Terr. for 1872, and which have become so generally known as the "Bear River Estuary Beds." They are there about 500 feet in thickness, and conformably with them, in upward order, about 200 feet in thickness of dark gray shales occur, which contain teliost fish-scales; but no other fossils were obtained from them. My examination of this neighborhood added little to a knowledge of these strata beyond that which had already been published by Mr. Meek and Mr. King, except that I found them quite fully exposed on the west side of the river, which fact is not shown on Mr. King's map, nor mentioned by Mr. Meek. My collections, however, embrace some species not before known.

The Laramie strata of the other neighborhood comprise the exact equivalents of those near Mellis Station, and contain an abundance of the same fossils, together with the Evanston coal series, the best development of which appears at the little hamlet of Almy, three miles northward from Evanston. From that point to about four miles farther north-

ward these Laramie strata are found exposed in the east valley-side of Bear River. This coal-bearing series contains an entirely different fauna from that of the beds beneath; but because of its apparent stratigraphical conformity with them, and the fact that some of its fossils have been identified with Laramie fossils elsewhere, I refer the whole to the Laramie Group. The equivalent strata in this neighborhood of the dark gray shales in the other, which contain the teliost fish-scales, are a little greater in aggregate thickness, and a portion of them are composed of thicker layers, but their identity is easily recognized. For convenience of reference in the following remarks I shall designate these, together with the coal-bearing series, as the "upper beds"; and those beneath them, containing the brackish-water fossils, I shall, for the same purpose of local reference and present discussion, use the term "lower beds." Of invertebrate fossils only fresh-water and land shells have been found in the upper beds, and these only at the Almy or Evanston-coal mines; but those of the lower strata embrace both brackish and fresh water molluscan forms, the latter including a few palustral pulmonates. Among those brackish and fresh water forms are two or three types which have never been recognized except in these lower beds or their immediate equivalents, and nearly their whole fauna is in marked contrast with that of any other portion of the Laramie Group. The following list is intended to embrace all the invertebrate fossils that have hitherto been found in the Laramie strata of Bear River Valley within the limits of Southwestern Wyoming:

LIST OF LARAMIE FOSSILS FROM BEAR RIVER VALLEY, WYOMING.

1. *Membranipora* ?
2. *Ostrea* ——— ?
3. *Volsella* ——— ?
4. *Unio vetustus* Meek.
5. *Unio belliplicatus* Meek.
6. *Pisidium saginatum* White.
7. *Sphærium* ——— ?
8. *Corbicula* (*Veloritina*) *durkeei* Meek.
9. *Corbula pyriformis* Meek.
10. *Corbula Englemanni* Meek.
11. *Rhytophorus priscus* Meek.
12. *Rhytophorus meeki* White.
13. *Limnæa* (*Limnophysa*) *nitidula* Meek.
14. *Acella haldemani* White.
15. *Planorbis* ——— ?
16. *Bulinus longiusculus* Meek & Hayden.
17. *Bulinus subelongatus* Meek & Hayden.
18. *Bulinus disjunctus* White.
19. *Macrocyclis spatiosa* Meek & Hayden?
20. *Helix evanstonensis* White.
21. *Columna teres* Meek & Hayden.
22. *Neritina naticiformis* White.
23. *Goniobasis arcta* Meek.
24. *Goniobasis cleburni* White.
25. *Goniobasis chrysallis* Meek.
26. *Goniobasis chrysaloidea* White.
27. *Goniobasis endlichi* White.
28. *Pyrgulifera humerosa* Meek.
29. *Hydrobia recta* White.

30. *Viviparus couesi* White.
31. *Campeloma macrospira* Meek.
32. *Spirorbis ?*
33. *Cypris* ——— ?
34. *Cycloid fish-scales.*
35. *Nutlets of Chara.*

NOTES ON THE LARAMIE FOSSILS OF BEAR RIVER VALLEY, WYOMING.

1. *Membranipora ?*

Some fragments of a Polyzoan were found incrusting the surface of *Corbula pyriformis* and other shells of the lower beds, which are apparently of the same species as those found on the oyster-shells at Point of Rocks, mentioned on a former page. They are too imperfect for satisfactory classification, but are of some value as additional evidence of at least some degree of saltness of the water in which the associated mollusks lived.

2. *Ostrea* ——— ?

A few separate valves of an undetermined species of *Ostrea* were found here and there in the lower beds; and in some places a thin layer was found mainly composed of them. They are all comparatively small shells, and all seem to have been somewhat waterworn before being finally imbedded.

3. *Volsella* ——— ?

A couple of fragments only of a small undetermined species of this genus were found near Mellis Station.

4. *Unio vetustus* Meek.

Shells of this species are quite abundant in the lower beds, a large proportion of which have both valves unseparated. It is figured and described in vol. iv, U. S. Geol. Sur. 40th Parallel, and also in U. S. Expl. Great Basin of Utah (Simpson).

5. *Unio belliplicatus* Meek.

This species is found associated with No. 4 and in similar condition; but it is not quite so abundant. It is figured and described in vol. iv, U. S. Geol. Sur. 40th Parallel. This species is an interesting one because of the fact that its style of surface ornamentation is different from that of any other known North American species, either fossil or recent.

6. *Pisidium saginatum* White.

Only three or four examples of this species were discovered, and these only at the Evanston coal-mines, in the upper Laramie beds there.

7. *Sphærium* ——— ?

A few casts only of a small species of this genus were found associated with numerous other small fresh-water shells in a gray clayey layer, about 40 feet above the principal bed of coal at the Evanston mines.

8. *Corbicula* (*Veloritina*) *durkeei* Meek.

A large number of examples of this species exist in the lower beds wherever they have been exposed. It is the type of Meek's subgenus *Veloritina*, and is described and figured by him in vol. iv, U. S. Geol. Sur. 40th Parallel. Among the collections made by Lieutenant Wheeler's parties in the valley of Virgen River, Southern Utah, I identified this species, and figured and described it in vol. iv, U. S. Expl. and Sur. West of the 100th Merid.

9. *Corbula pyriformis* Meek.

This is also an abundant species in the lower beds, and, like many of its associated bivalves, a large proportion of the examples have both valves unseparated. It is figured and described in vol. iv, U. S. Geol. Sur. 40th Parallel and also in U. S. Expl. Great Basin of Utah (Simpson).

10. *Corbula englemanni* Meek.

Probably only a variety of No. 9 (*loc. cit.*).

11. *Rhytophorus priscus* Meek.

This is evidently a littoral pulmonate, closely related to *Melampus*, and it doubtless had a similar saline habitat. It is the type of the genus, and is described and figured by Meek in vol. iv, U. S. Geol. Sur. 40th Parallel, and also in U. S. Expl. Great Basin of Utah (Simpson).

12. *Rhytophorus meekii* White.

This is possibly only a variety of No. 11, but the observable differences seem to be of specific value. It is described in Powell's Report on the Geology of the Uinta Mountains, p. 118.

13. *Limnæa nitidula* Meek.

Mr. Meek figured and described this species in vol. iv, U. S. Geol. Sur. 40th Parallel. It is quite abundant in some of the layers near Mellis Station, where it is associated with numerous fresh- and brackish-water forms.

14. *Acella haldemani* White.

Among the siliceous *debris* remaining after an acid solution of some pieces of calcareous shaly rock found among the fossiliferous layers near Mellis Station, several examples of this species were discovered. It has never been discovered elsewhere, and so far as I am aware no other species of this genus has ever been found fossil. It is important as adding another indication of the great degree of differentiation which the pulmonate mollusca had attained at that early epoch. It is described in Bull. U. S. Geol. Sur. Terr. vol. iv, p. 714.

15. *Planorbis* ——— ?

Among the *debris* associated with Nos. 14 and 15, numerous examples of a minute *Planorbis* were found. They are all of nearly uniform size, which suggests the possibility that they are adult; but they are probably young examples of a larger species. No other examples of *Planorbis* were found in the lower beds, but in the upper ones at the Evanston coal-mines some fragments of another but undetermined species were found.

16. *Bulinus longiusculus* Meek & Hayden.

Among a considerable number of examples found in the upper beds at the Evanston coal-mines, referable to *Bulinus*, are some that I refer with some confidence to *B. longiusculus* and *B. subelongatus* respectively. The former was originally discovered in the Fort Union, and the latter in the Judith River beds, both in the Upper Missouri River region; and both are figured and described in vol. ix U. S. Geol. Sur. Terr.

17. *Bulinus subelongatus* Meek & Hayden.

A single specimen found associated with Nos. 13, 14, 15, and others in the lower beds near Mellis Station, appears to belong to this species. See, also, remarks under No. 16.

18. *Bulinus disjunctus* White.

This species is described in a foot-note on page 170 of this report. It has been found in the Laramie beds of the valley of Crow Creek, Eastern Colorado, and in the upper beds at the coal-mines near Evanston, Wyo., there is a form which is probably specifically identical with it.

19. *Macrocyclis spatiosa* Meek & Hayden?

A species evidently referable to this genus, and, so far as the somewhat imperfect examples will admit of comparison, seems to be identical with *M. spatiosa*, was found in the upper beds at the Evanston coal-mines. This species is described and figured by Mr. Meek in vol. ix, U. S. Geol. Sur. Terr., and is there referred to the Wind River Group. Overlooking this fact, but following a general label found accompanying a tray of Upper Missouri fossils, among which were the types of both this species and *Columna teres* Meek & Hayden, I referred them both to the Judith River Group in the table on page 722, Bull. U. S. Geol. and Geog. Sur. Terr. vol. iv. Concerning the *Columna*, the error, if it be one, amounts to but little, as it is now well known that several species of fossils which respectively characterize the Judith River and Fort Union beds, are associated together in the same strata of the Laramie Group elsewhere. As to the *Macrocyclis* I can at present only say that the examples which I obtained from the Upper Laramie beds at the Evanston coal-mines in Bear River Valley answer well to the description and figures of *M. spatiosa* given by Mr. Meek. It is true my examples are not perfect, and it may be that when better ones are found they will show specific differences from the types of *M. spatiosa.*

20. *Helix evanstonensis* White.

This species was found in the upper beds at the Evanston coal-mines, and is described in Bull. U. S. Geol. and Geog. Sur. Terr. vol. iv, p. 714, where the mention of its locality was inadvertently omitted.

21. *Columna teres* Meek & Hayden.

So far as the specimens will admit of comparison this species appears to be identical with *C. teres* from the Fort Union beds of the Upper Missouri River region, the type of which is figured in vol. ix U. S. Geol. Sur. Terr. (See remarks under No. 19.)

22. *Neritina naticiformis* White.

This small shell was found quite plentifully in certain of the clayey layers of the lower beds near Mellis Station, but it has not been discovered elsewhere. It is described in Bull. U. S. Geol. and Geog. Sur. Ter., vol. iv, p. 715.

23. *Goniobasis arcta* Meek.

Associated with Nos. 13 and 22 and other species in the lower beds near Mellis Station numerous examples have been found which answer to the figure and description of *G. arcta* as given by Meek in U. S. Expl. Great Basin of Utah (Simpson). The locality is there given as "Ham's Fork," but this reference is probably an error, as was that of its associate (No. 13 *Limnæa* (*Limnophysa*) *nitidula*), as shown by Mr. Meek in U. S. Geol. Sur. 40th Parallel, vol. iv, p. 182.

24. *Goniobasis cleburni* White.

This, together with the two following species, which have been found only in the lower beds of the Bear River Group in Bear River Valley, forms a natural group, which might properly be regarded as a section

under *Goniobasis.* It is described in Powell's Report on the Geology of the Uinta Mountains, p. 122.

25. *Goniobasis chrysallis* Meek.

Described in An. Rep. U. S. Geol. Sur. Terr. for 1870, p. 316. (See remarks under No. 24.)

26. *Goniobasis chrysaloidea* White.

Described in Powell's Report on the Geology of the Uinta Mountains, p. 123. The figure given by Professor Hall in Fremont's Exploration of Oregon and Northern California of his *Cerithium Fremonti* so much resembles this species as to suggest the possibility that it may be identical. (See remarks under No. 24.)

27. *Goniobasis endlichi* White.

This is rather a rare species, having been found only in the lower beds seven miles northward from Evanston, where it is associated with the common species of those beds. It posesses the raised revolving lines of the three foregoing species, but is without their longitudinal varices or ridges. It is described in the Bull. U. S. Geol. and Geog. Sur. Terr., vol. iv, p. 716. In the Evanston coal-mines some fragments of a species have been obtained which indicate that it resembles this in its surface markings, but that it is a smaller and more slender species.

28. *Pyrgulifera humerosa* Meek.

This is one of the most abundant and characteristic species of the lower beds of the Laramie Group in Bear River Valley. Mr. Meek made it the type of his genus *Pyrgulifera*, and described and figured it in the U. S. Geol. Sur. 40th Parallel; and also in U. S. Expl. Great Basin of Utah (Simpson). It is probably a widely-distributed species in the equivalents of the Bear River Laramie. Among some fossils brought by Professor Powell from Upper Kanab, Southern Utah, I have recognized this species, together with some which characterize the Laramie Group farther eastward, but I do not know whether they were there associated together in the same layers.

29. *Hydrobia recta* White.

This species has been found only in the upper beds at the coal-mines, three miles from Evanston. It is associated with fresh-water and land shells only, and is probably not a true *Hydrobia*, but the condition of the specimens does not warrant a conclusive reference to any other genus. It is described in Powell's Report on the Geology of the Uinta Mountains, p. 132.

30. *Viviparus couesi* White.

This is the largest species of *Viviparus* known to me. It has has been found only in the lower Laramie beds of the Bear River Valley, but examples of it have been obtained wherever those strata have been examined by me. It is described in the Bulletin U. S. Geol. Sur. Terr. vol. iv, p. 717. Mr. Meek gave two figures of an imperfect example of it in U. S. Geol. Sur. 40th Parallel, vol. iv, pl. 17, fig. 15 and 15*a*, under the generic name of *Campeloma*, but without a specific name. It has the straight outer lip and other characteristics of *Viviparus*, and not the sinuate outer lip of *Campeloma*.

31. *Campeloma macrospira* Meek.

This species is associated with No. 30, and has been found in considerable numbers wherever the lower beds are exposed in Bear River Valley.

Mr. Meek describes it and figures an imperfect example in the United States Geological Survey 40th Parallel.

32. *Spirorbis?*

Near Mellis Station some examples of a minute coiled shell resembling a *Spirorbis* were found attached to *Unio vetustus* and other associated shells. It is possible that they are the first coils or young examples of the *Planorbis*, No. 15, but they seem to have been of a parasite or commensal habit. Water that was salt enough for *Corbula*, *Membranipora*, &c., would no doubt have been congenial for *Spirorbis*.

33. *Cypris* ——— ?

Multitudes of casts of a species of Cypris were found in the gray clayey shale, 40 feet above the principal bed of coal at the Evanston coal mines, belonging to the upper Laramie beds.

In this soft, clayey shale were also found, besides the *Sphærium* and *Cypris* already mentioned the casts of numerous other small shells, mostly those of *Physa* or *Bulinus*; and in addition to these, a few cycloid fish-scales; also associated with Nos. 37 and 38 numerous minutes nutlets of a species of *Chara* were found.

Besides the species enumerated or referred to in the foregoing list, there are among the collections, especially those from the upper beds, fragments that indicate the existence of several yet undetermined species of invertebrate fossils.

In all the other collections of Laramie fossils that have been discussed in this report some species are represented which connect the strata of the different localities from which they respectively came, as unmistakably belonging to the great Laramie Group; but a comparison of the collections from the lower beds of Bear River Valley with all the other collections of Laramie fossils is one entirely of contrast, so far as specific identity is concerned, unless the *Bulinus* mentioned under No. 17 be an exception. Moreover, as has already been mentioned, these lower beds of the Bear River Laramie contain two or three molluscan types of generic or subgeneric value, that have never been found elsewhere, besides some other modifications of type perhaps of less value than the others, but still sufficiently characteristic.

Inquiring into the inhabitancy of the whole fauna of these lower beds we do not find an indication that its condition, so far as saltness of the water is concerned, was materially different from that of the brackish-water fauna of the Laramie Group in general, there being always, and in the case of both faunæ, a mixture of both brackish and fresh water forms, with some palustral pulmonates and an occasional land shell. The marked difference, then, between the invertebrate fauna of the lower beds of Bear River Laramie and that of the group in general is not such as is produced by a change in the saltness or by a complete freshening of the inhabited waters; but it is evidently due to other causes. My own investigations of these strata have been far too limited to warrant any present discussion of the causes that have produced these faunal differences, but there seems to be little room for doubt that it was due in large part to conditions consequent upon the proximity and character of the western shore of the Laramie sea. It will also be remembered that the Cretaceous fauna of the Coalville series, which occupies a similar relative geological position, shows almost if not equally as great a contrast with that of its assumed equivalent strata which occupy the same regions farther eastward with the various Laramie strata herein discussed. But after all the inquiry naturally arises, are these Bear River beds properly referable to the Laramie Group, and, if so, are they true equivalents of those Lara-

mie strata that have already been discussed in this report? Too much yet remains to be done in the investigation of these beds and their fauna to admit of definite replies to these questions, but the following already ascertained facts have an important bearing upon them. In the section published by Mr. Meek in the An. Rep. U. S. Geol. Sur. Terr. for 1872, p. 451, these brackish-water Laramie beds are seen to come in the series above the Fox Hill Cretaceous strata. In the neighborhood extending from three to seven miles north from Evanston the coal series is seen to rest upon the brackish-water beds, and in turn to be overlaid by the Wasatch Group. This warrants their general reference to the Laramie Group, but whether they may not be older than any of the other Laramie strata that have been discussed in this report remains for further investigation to decide. The fact that some of the invertebrate types of these brackish-water beds are apparently extinct, while none of those of the other Laramie beds are now known to be so, suggests their greater antiquity, but does not necessarily prove it; especially so as those types are not known in older strata. On the other hand some of the species in the upper beds at the Almy coal mines, some 400 or 500 feet above the range of the brackish-water species, are regarded as identical with forms that have been found both in the Fort Union and the Lignitic beds of the Laramie Group east of the Rocky Mountains in Colorado. It should furthermore be remarked that the conditions of the strata at the junction of the Fox Hills Group with the brackish-water Laramie beds in this region are not accurately known; and also that I am not sure of the exact conformity of the coal-bearing upper beds upon the latter; while the unconformity of the Wasatch, upon the Laramie *in this region*, is well known to be general. It therefore seems not improbable that the displacements which took place in this region were not confined to the immediate close of the Laramie period, but that other lesser movements took place at different times between the close of the Fox Hills epoch and the earlier part of that of the Wasatch.

The displacements that took place at or near the close of the Laramie period, in what is now the vicinity of Bear River Valley, were very great, and they are doubtless of considerable extent in this region, although not at all apparent in a large part of the Green River Basin. They involved not only the Laramie strata, but the older groups also; at least those of the Fox Hills and Colorado Groups, which are seen to be so involved in this immediate neighborhood, if the latter have been correctly identified. This is shown in Mr. Meek's section of the strata in the valley of Sulphur Creek at its confluence with Bear River, which has already been referred to. That section shows not only abrupt and deep foldings of those strata, but certain slips or faults also. The portion of it which is numbered 28 consists of the brackish-water Laramie beds as they are seen at Mellis Station on the east side of Bear River, and which there appear to occupy the east side of an abrupt synclinal fold. No strata above those of the Laramie Group appear to be involved in this sharp fold, against the upturned strata of which those of the Wasatch Group appear to abut unconformably. The whole group is probably thus involved, but the upper beds, as seen at the Evanston coal-mines, have not been discovered there, the waters and scattered shingle of Bear River covering the surface they would otherwise occupy if present. The Laramie strata that occupy the western side of the fold appear upon the western side of Bear River, a couple of miles southwestwardly from Mellis Station, those of both sides of the fold being nearly perpendicular.

Flanking these upturned Laramie strata upon their west side, and in

contact with them, I found a small exposure of Fox Hills strata, which are composed of soft sandstones and, like the Laramie strata there, they are nearly vertical. From one of these Fox Hill's layers I obtained a small collection of fossil shells, all of which are imperfect, and some of the species which they indicate are not recognizable. The identification of those of the following list is probably correct, and shows an intimate relation of these strata with those of the Coalville series.

LIST OF CRETACEOUS FOSSILS FROM THE VALLEY OF BEAR RIVER, WYOMING.

1. *Ostrea*———?
2. *Volsella* (*Brachydontes*) *multilinigera* Meek.
3. *Nucula*———?
4. *Barbatia coalvillensis* White.
5. *Cardium trite* White?
6. *Cyrena securis* Meek.
7. *Tellina? modesta* Meek.
8. *Tellina* (*Arcopagia?*) *utahensis* Meek.
9. *Corbula dubiosa* White.*

NOTES ON THE CRETACEOUS FOSSILS OF BEAR RIVER VALLEY.

1. *Ostrea*———?

The examples of this oyster are numerous and many of them well preserved, but they are all small, and so wanting in specific characters that they cannot be satisfactorily identified with any published species or described as new. They are possibly identical with *O. coalvillensis* Meek.

2. *Volsella* (*Brachydontes*) *multilinigera* Meek.

This species was originally discovered by Meek at Coalville. It also occurs near Hilliard Station, four miles east of this locality.

3. *Nucula*———?

The examples are too imperfect for specific determination. They indicate a species much like *N. planimarginata* Meek & Hayden.

4. *Barbatia coalvillensis* White.

Hitherto discovered only at Coalville. (See remarks under head of Cretaceous fossils of that locality.)

5. *Cardium trite* White.

The examples found here are only imperfect casts, but the surface markings are more nearly like those of *C. trite* than those of either *C. curtum* or *C. subcurtum*, the only two other species of *Cardium* that are likely to be found in these strata. *C. trite* was discovered at the head of Waterpocket Cañon, Utah, by Mr. Gilbert, and is described and figured in another part of this volume.

6. *Cyrena securis* Meek.

This species has been discovered at Coalville and also at Hilliard Station, four miles east of this locality. It is described and figured in another part of this volume.

7. *Tellina? modesta* Meek.

A Coalville species. (See remarks under that head.)

8. *Tellina* (*Arcopagia?*) *utahensis* Meek.

See remarks under notes on Coalville fossils.

* See following remarks under No. 9.

9. *Corbula dubiosa* White.

This species has never been described. It is the one that has been referred to at different times by myself and Mr. Meek when discussing the fossils of Coalville, and is figured by Mr. Meek in U. S. Geol. Sur. 40th Parallel, vol. iv, pl. 14, f. 2. It appears so often among the Cretaceous fossils of this region, although the examples are usually imperfect, that the foregoing name is given to it, provisionally, as a matter of convenience.

Crossing Bear River we proceeded eastward up the valley of Sulphur Creek, along the line of Mr. Meek's section, as given in An. Rep. U. S. Geol. Sur. Terr. for 1872, p. 451, and which has already been referred to in relation to the Laramie strata of Bear River Valley. From No. 12 of that section, immediately overlying the bed of coal* there, I collected numerous examples of *Inoceramus problematicus* Schlotheim, and a few imperfect examples of *Anchura fusiformis* Meek? These strata belong without doubt within the limits of the consolidated Fox Hills Group, notwithstanding the presence there of *Inoceramus problematicus.*

Continuing up the valley to Hilliard Station I obtained the fossils of the following list from Fox Hills strata there which are not represented in Mr. Meek's section, but which are equivalent with some of those within that section about three miles further westward.

LIST OF CRETACEOUS FOSSILS COLLECTED AT HILLIARD STATION, WYOMING.

1. *Ostrea soleniscus* Meek.
2. *Placunopsis hilliardensis* White.
3. *Volsella (Brachydontes) multilinégera* Meek.
4. *Cardium curtum* Meek & Hayden.
5. *Cardium subcurtum* Meek.
6. *Cyrena securis* Meek.
7. *Corbula dubiosa* White.
8. *Neritina incompta* White.
9. *Turbonilla (Chemnitzia?) coalvillensis* Meek.

NOTES ON THE CRETACEOUS FOSSILS OF HILLIARD STATION.

1. *Ostrea soleniscus* Meek.

This species is common in the vicinity of Coalville, and, so far as I am aware, it has never been found except in this region, bordering the western side of the Green River Basin. It seems also to have a great vertical range within the Fox Hills Group.

2. *Placunopsis hilliardensis* White.

Discovered only at this locality. It is described and figured in another part of this volume.

3. *Volsella (Brachydontes) multilinigera* Meek.

See remarks under head of notes on Cretaceous fossils of Coalville, and also on those of Bear River Valley.

4. *Cardium curtum* Meek & Hayden.

See remarks under head of notes on Cretaceous fossils of Coalville.

* The mining of this coal was abandoned with the abandonment of Old Bear River City, upon the site of which it was formerly worked. It has been thought that this bed of coal is equivalent with the lower one at Coalville, but it is more probably equivalent with that of Carleton's mine, at the same place.

5. *Cardium subcurtum* Meek.

See remarks under head of notes on Cretaceous fossils of Coalville.

6. *Cyrena securis* Meek.

See remarks under head of notes on Cretaceous fossils of Bear River Valley, and also on those of Coalville.

7. *Corbula dubiosa* White.

See notes on Cretaceous fossils of Bear River Valley.

8. *Neritina incompta* White.

Discovered only at this locality. It is described and figured in another part of this volume.

9. *Turbonilla* (*Chemnitzia?*) *coalvillensis* Meek.

See remarks under head of notes on Cretaceous fossils of Coalville. It is described and figured in another part of this volume.

A glance at these collections from Bear River Valley and near Hilliard Station, in the valley of Sulphur Creek, the two localities being only about four miles apart, shows that the Cretaceous invertebrate fauna here, although much less fully represented, is essentially the same, and quite as peculiar as that of Coalville. In discussing the Coalville fossils it was shown that we may expect to find a similar Cretaceous fauna south of the Uinta, and east of the Wasatch Mountains; and it now appears equally certain that we shall find that peculiar fauna to extend further northward than the valley of Bear River.

In connection with the strata which are exposed along the valley of Sulphur Creek, a part only of which are represented in Mr. Meek's section, there are some near Hilliard Station that appear to possess the peculiar characteristics of the Colorado Group, but which inclement weather prevented me from investigating. If this supposition be correct, the strata coming in the series between them and those of the Laramie Group of course belong to the consolidated Fox Hills Group. As these strata here have an aggregate thickness of not less than 3,000 feet, it is probable that the whole fossiliferous series of Cretaceous rocks at Coalville are referable to the same group; especially so as, almost without exception, the fossils of the Bear River and Sulphur Creek strata have been recognized in the Coalville series.

While making the foregoing observations in the valleys of Bear River and Sulphur Creek, a fall of snow gave admonition of the approaching close of the season, and I therefore then went eastward to Green River, crossing it at Green River City. From there I passed up Bitter Creek, a tributary of Green River, and the weather being then favorable, I made the observations upon the Laramie strata there, which have been recorded on preceding pages of this report.

From Black Buttes Station eastward to Bitter Creek Station our route was over the strata of the Wasatch Group, the dip being gently to the eastward, but becoming very slight or hardly perceptible in the neighborhood of the last-named station. From this station our route was near to and parallel with the Union Pacific Railroad until we left the field at Rawlins' Springs. As far east as Red Desert Station our course seemed to be directly upon the line of strike, and near or upon the division between the Wasatch and Green River Groups. In this region as well as at other places where I have examined these two groups near their junction, it is impossible to say where one ends and the other begins. This is rendered still more difficult by the fact that the best known of the molluscan species of both groups range from the Wasatch up into the Green

River Group; and also by the fact that several similar fossiliferous horizons occur near to and both above and below the plane where, for stratigraphical reasons, we find it desirable to make the division between the two groups.

Among some of the better known molluscan species just referred to, I found in these debatable strata, about three miles east of Table Rock Station, a small undescribed *Planorbis*, which I have called *P. cirrus*.*

The last field-work that was done for the season was an examination of the Laramie strata between the continental watershed and the line of outcrop of the Fox Hills Group, between Separation Station and Rawlins Springs. These strata have there all their usual lithological characteristics, and their aggregate thickness is estimated at not much if any less than 4,000 feet. The only fossils found there were a few fragments of *Unio* and a single imperfect specimen of *Viviparus*, apparently *V. trochiformis* Meek & Hayden. These were obtained near the railroad about a mile eastward from Separation Station.

GENERAL DISCUSSION.

The desirability of extending an established classification of strata over the whole of a great region or portion of a continent is two manifest to need comment. Within limited areas the lithological characteristics of strata are, as a rule, alone sufficiently constant for the ready recognition of natural groups; and in the Western Territories there is so unusual a degree of constancy in this respect that certain of the established groups of strata can thus be satisfactorily recognized over very large areas. But even in the most favorable cases of this kind the fossil contents of the groups are the most trustworthy guides to their identity; while for their recognition over large or separate regions, their fossils are almost the only guides worthy of confidence. It is in view of these facts that the present plan for paleontological field-work has been established, the present report being that for the first season's labors of this kind.

The value of fossil collections for the purposes just indicated depends upon two circumstances, namely, the geographical distribution of the species and types, and their geological or vertical range; and for the purpose of giving a synoptical view of the species collected during this season's labors, together with their geographical distribution, the two following general tables have been prepared, the one of Cretaceous, and the other of Laramie fossils. Similar and equally instructive tables of any and all other groups might be prepared, but the present object is to embrace only the results of my field observations for the year 1877.

While there are, as has already been shown on preceding pages, some important exceptions to the rule of constancy of paleontological characteristics of both the Laramie and Fox Hills Groups, the results of this season's labors give great reason to hope that a perfectly harmonious classification may be established for the strata of both these and other epochs over the greater part of the national domain. These investigations have been quite sufficient to show that the grouping of the Cretaceous strata which was proposed several years ago by Hayden and

* This species has not been hitherto described, but may be characterized thus: Shell small, discoid; volutions six or seven, very slender, coiled closely and almost exactly in a plane so that the upper side is known only by the greater backward obliquity of the striæ of growth; their transverse diameter a little greater than the vertical; surface smooth or marked only by the ordinary striæ of growth. Diameter of the coil of the largest example discovered, 8 millimeters; transverse diameter of the last volution, 1½ millimeters.

Meek for the Upper Missouri River region constitutes a natural and reliable basis for the classification of the Cretaceous rocks of much the greater part if not all of the region embracing the Western States and Territories. The modification of that grouping which is followed in this report consists, as already explained on previous pages, only in omitting certain of the subdivisions which were recognized in the Upper Missouri River region, while the leading features are retained without change.

These labors have also demonstrated the unity of all the principal brackish-water deposits hitherto known in the Western Territories, and justified their recognition as a comprehensive group of strata under the name of the Laramie Group, which represents a great period in geological time, and especially such in the geological history of North America.

The known extent of the vertical range of each species named in the following table, within its own group of strata, has been indicated on previous pages in the notes that follow each list of the fossils which were collected at the localities visited during the season. Their geographical distribution is indicated by columns in the table which represent certain arbitrarily designated regions embracing the whole extent of my season's travels, to which is added for comparison a column representing the Upper Missouri River region.

Table showing the geographical distribution of the Cretaceous species collected during the season of 1877.

FOX HILLS GROUP.

	Upper Missouri River region.	Eastern Colorado.	Northwestern Colorado.	Coalville, Utah.	Bear River Valley.
1. *Caryophyllia egeria* White			×		
2. *Lingula nitida* Meek & Hayden	×		×		
3. *Ostrea patina* Meek & Hayden	×	× ?			
4. *Ostrea soleniscus* Meek				×	×
5. *Ostrea coalvillensis* Meek				×	× ?
6. *Ostrea congesta* Conrad				× ?	
7. *Ostrea (Alectryonia) sannionis* White				×	
8 *Placunopsis hilliardensis* White					×
9. *Pteria haydeni* Hall & Meek		×			
10. *Pteria linguiformis* Evans & Shumard	×	×	×		
11. *Pteria gastrodes* Meek				×	
12. *Pteria (Pseudoptera) fibrosa* Meek & Hayden	×	×			
13. *Pteria (Pseudoptera) rhytophora* Meek				×	
14. *Pteria (Pseudoptera) propleura* Meek				×	
15. *Pteria (Oxytoma) nebrascana* Evans & Shumard		×			
16. *Pinna lakesi* White		×			
17. *Inoceramus barabini* Morton	×		×		
18. *Inoceramus howelli* White			×		
19. *Inoceramus erectus* Meek				×	
20. *Inoceramus oblongus* Meek		×			
21. *Inoceramus vanuxemi* Meek & Hayden	×	×	×		
22. *Inoceramus pertenuis* Meek & Hayden			× ?		
23. *Inoceramus problematicus* Schlotheim				×	×
24. *Volsella (Brachydontes) multilinigera* Meek				×	×
25. *Crenella elegantula* Meek & Hayden	×	×			
26. *Nucula planimarginata* Meek & Hayden	×	×	×		
27. *Nucula cancellata* Meek & Hayden	×	×			
28. *Barbatia coalvillensis* White				×	×
29. *Sphæriola? obliqua* Meek		×			
30. *Sphæriola? endotrachys* Meek	×	×			
31. *Tancredia americana* Meek & Hayden	×	×			
32. *Tancredia? cœlionotus* White		×			
33. *Veniella humilis* Meek & Hayden	×	×			
34. *Cardium speciosum* Meek & Hayden	×	×	×		
35. *Cardium curtum* Meek & Hayden				×	×
36. *Cardium subcurtum* Meek				×	×
37. *Cardium trite* White					× ?
38. *Protocardia rara* Evans & Shumard	×	×			

Table showing the geographical distribution of the cretaceous species collected, &c.—Cont'd.

FOX HILLS GROUP—Continued.

	Upper Missouri River region.	Eastern Colorado.	Northwestern Colorado.	Coalville, Utah.	Bear River Valley.
39. *Protocardia subquadrata* Evans & Shumard	×	×	......	......	......
40. *Cyrena carletoni* Meek	......	......	......	×	......
41. *Cyrena securis* Meek	......	......	......	×	×
42. *Callista deweyi* Meek & Hayden	×	×	......	......	......
43. *Thetis? circularis* Meek & Hayden	×	......	× ?	......	......
44. *Tellina scitula* Meek & Hayden	×	×	......	......	......
45. *Tellina equilateralis* Meek & Hayden	×	× ?	......	......	......
46. *Tellina? isonema* Meek	......	......	......	×	......
47. *Tellina? modesta* Meek	......	......	......	×	×
48. *Tellina (Arcopagia) utahensis* Meek	......	......	......	×	......
49. *Cyprimeria? subalata* Meek	......	......	......	×	......
50. *Corbula nematophora* Meek	......	......	......	×	......
51. *Corbula dubiosa* White	......	......	......	×	×
52. *Mactra holmesii* Meek	......	×	......	......	......
53. *Mactra (Cymbophora) alta* Meek & Hayden	×	×	×	......	......
54. *Mactra (Cymbophora) warrenana* Meek & Haydend	×	×	×	......	......
55. *Glycimeris berthoudi* White	......	×	......	......	......
56. *Pachymya? herseyi* White	......	×	......	......	......
57. *Dentalium gracile* Hall & Meek	×	×	......	......	......
58. *Cylichna scitula* Meek & Hayden	×	×	......	......	......
59. *Actæon woosteri* White	......	×	× ?	......	......
60. *Actæonina prosocheila* White	......	×	......	......	......
61. *Anisomyon centrale* Meek	......	×	......	......	......
62. *Melampus antiquus* Meek	......	......	......	×	......
63. *Physa carletoni* Meek	......	......	......	×	......
64. *Neritina bannisteri* Meek	......	......	......	×	......
65. *Neritina incompta* White	......	......	......	......	×
66. *Neritina pisum* Meek	......	......	......	×	......
67. *Neritina pisiformis* Meek	......	......	......	×	......
68. *Neritina (Velatella) bellatula* Meek	......	......	......	×	......
69. *Neritina (Velatella) carditoides* Meek	......	......	......	×	......
70. *Neritina (Velatella) patelliformis* Meek	......	......	......	×	......
71. *Lunatia subcrassa* Meek & Hayden	×	×	......	......	......
72. *Euspira coalvillensis* White	......	......	......	×	......
73. *Gyrodes depressa* Meek	......	......	......	×	......
74. *Anchura haydeni* White	......	×	......	......	......
75. *Anchura fusiformis* Meek	......	......	......	×	×
76. *Anchura americana* Evans & Shumard	×	×	......	......	......
77. *Turritella coalvillensis* Meek	......	......	......	×	......
78. *Turritella spironema* Meek	......	......	......	×	......
79. *Turritella (Aclis?) micronema* Meek	......	......	......	×	......
80. *Turbonilla (Chemnitzia?) coalvillensis* Meek	......	......	......	×	×
81. *Eulimella? inconspicua* Meek	......	......	......	×	......
82. *Eulimella? chrysallis* Meek	......	......	......	×	......
83. *Eulimella? funicula* Meek	......	......	......	×	......
84. *Pseudobuccinum nebrascense* Meek & Hayden	×	×	......	......	......
85. *Fasciolaria (Piestocheilus) culbertsoni* Meek & Hayden	×	×	......	......	......
86. *Valvata nana* Meek	......	......	......	×	......
87. *Fusus (Neptunea?) gabbi* Meek	......	......	......	×	......
88. *Fusus (Neptunea?) utahensis* Meek	......	......	......	×	......
89. *Admetopsis rhomboidea* Meek	......	......	......	×	......
90. *Admetopsis gregaria* Meek	......	......	......	×	......
91. *Admetopsis subfusiformis* Meek	......	......	......	×	......
92. *Baculites ovatus* Say	×	×	×	× ?	......
93. *Scaphites nodosus* Owen	×	×	×	......	......
94. *Scaphites mandanensis* Morton	×	×	......	......	......
95. *Placenticeras lenticulare* Owen	×	×	......	......	......
96. *Placenticeras placenta* Dekay	×	×	......	......	......

COLORADO GROUP.

1. *Ostrea congesta* Conrad	×	×		......	......
2. *Inoceramus problematicus* Schlotheim	×	×		......	......
3. *Inoceramus deformis* Meek	......	×	×	......	......

NOTE.—The species that, on account of the imperfection of the specimens, have not been satisfactorily recognized, are not included in this list, as they are in the local lists.

The column representing the Upper Missouri River region is added for purposes of comparison, in recognition of the classification which has been established by Hayden and Meek for the Cretaceous strata there, as a standard for all the Cretaceous strata of the Western Territories. The existence of the species there which are named in the list is given on the authority of those authors, as I have never yet visited that region in person. The column assigned to Eastern Colorado includes, for the present purpose, only that portion of it, east of the Rocky Mountains, which I visited during the season; and the same may be said of the column assigned to Northwestern Colorado. The column assigned to Coalville is intended to include the whole valley of Weber River in that neighborhood; and the one assigned to Bear River Valley includes also the adjacent portion of the Valley of Sulphur Creek up to Hilliard Station.

In the table of the Laramie fossils next following, one of the vertical lines separating the columns which represent localities or regions is made double, to indicate the fact that those upon one side of it are east, and those upon the other side of it west, of the Rocky Mountains. Such a modification might be made in this one, but it is hardly necessary, because few facts are more patent than that the elevation of the Rocky Mountains began long after the deposition of the latest strata represented in the table.

It will, of course, be understood that this table embraces only the collections made either by myself or others at the localities which I visited during the season of 1877. It not only does not represent the full geographical distribution of those species, but it is probable that many other species will yet be found in some of the localities which have been thus visited. There is a notable paucity of the species of the Colorado Group represented in the table. This is in large part due to the fact that its strata in the region I traversed are less fossiliferous than those of the Fox Hills Group are; partly to the fact that, being softer, they are less freely exposed, and partly, that they came less in the way of my season's investigations.

The construction of the following table of the Laramie fossils which have been collected from the various regions visited by myself during the season of 1877 is similar to that of the preceding table of the Cretaceous fossils. The species are not only thus tabulated for a synoptical view, but the table shows the present known extent of their geographical distribution, and demonstrates the fact that all the principal brackish-water beds yet known in the Western Territories are members of one comprehensive group of strata representing a great period in the geological history of North America. The two columns representing the Judith River and Fort Union beds, respectively, are introduced for purposes of comparison, and to show their geological equivalency with the strata of the other localities. The species indicated in those two columns are given on the published authority of Hayden and Meek, as I have not yet visited the Upper Missouri River region in person. The two columns designated respectively as Eastern and Northwestern Colorado are of course intended to include only the species that have been collected at the localities which I have visited in person, and which have been discussed on preceding pages of this report. The column assigned to Bitter Creek includes the whole series of Laramie strata there: the differences in the fauna at different horizons of the series having already been shown are not repeated here. The column assigned to Bear River Valley includes the species of both brackish and fresh water beds that are found in the district extending from the mouth of Sulphur Creek to seven miles northward from Evanston, Wyo.

Table showing the geographical distribution of the fossils of the Laramie Group, collected during the season of 1877.

	Judith River beds.	Fort Union beds.	Eastern Colorado.	Northwestern Colorado.	Bitter Creek Valley.	Bear River Valley.
1. *Membranipora?*					×	×
2. *Ostrea glabra* Meek & Hayden	×		×	×	×	
3. *Anomia micronema* Meek			×	×	×	
4. *Anomia gryphorhynchus* Meek			×	×	×	
5. *Volsella (Brachydontes) regularis* White			×	×	×	
6. *Volsella (Brachydontes) laticostata* White				×		
7. *Nuculana inclara* White				×		
8. *Anodonta parallela* White			×			
9. *Unio vetustus* Meek						×
10. *Unio belliplicata* Meek						×
11. *Unio couesi* White					×	
12. *Unio propheticus* White					×	
13. *Unio aldrichi* White					×	
14. *Unio proavitus* White					×	
15. *Unio holmesianus* White					×	
16. *Unio endlichi* White					×	
17. *Unio cryptorhynchus* White	×				×	
18. *Unio brachyopisthus* White					×	
19. *Unio goniambonatus* White					×	
20. *Unio danæ* Meek & Hayden	×				×?	
21. *Pisidium saginatum*						×
22. *Corbicula occidentalis* Meek & Hayden	×			×	×	
23. *Corbicula cytheriformis* Meek & Hayden	×				×	
24. *Corbicula cleburni* White			×			
25. *Corbicula obesa* White			×			
26. *Corbicula cardiniæformis* White			×			
27. *Corbicula (Leptesthes) fracta* Meek			×	×	×	
28. *Corbicula (Leptesthes) planumbona* Meek			×			
29. *Corbicula (Leptesthes) macropistha* White			×			
30. *Corbicula (Leptesthes) subelliptica* Meek & Hayden	×		×			
31. *Corbicula (Veloritina) durkeei* Meek						×
32. *Corbula subtrigonalis* Meek & Hayden	×		×	×	×	
33. *Corbula pyriformis* Meek						×
34. *Corbula undifera* Meek				×	×	
35. *Rhytophorus priscus* Meek						×
36. *Rhytophorus meeki* White						×
37. *Limnæa (Limnophysa) nitidula* Meek						×
38. *Acella haldemani* White						×
39. *Bulinus disjunctus* White			×			×
40. *Bulinus subelongatus*, Meek & Hayden	×		×			×
41. *Bulinus longiusculus* Meek & Hayden		×				×
42. *Physa felix* White			×			
43. **Macrocyclis spatiosa* Meek & Hayden						×?
44. *Helix evanstonensis* White						×
45. *Columna teres* Meek & Hayden		×				×
46. *Neritinia naticiformis* White						×
47. *Neritinia volvilineata* White				×	×	
48. *Neritina (Velatella) baptista* White					×	
49. *Goniobasis arcta* Meek						×
50. *Goniobasis cleburni* White						×
51. *Goniobasis endlichi* White						×
52. *Goniobasis chrysallis* Meek						×
53. *Goniobasis chrysalloidea* White						×
54. *Goniobasis gracilienta* Meek & Hayden	×		×		×	
55. *Goniobasis nebrascensis* Meek & Hayden		×	×			
56. *Cassiopella turricula* White					×	
57. *Melania wyomingensis* Meek			×	×	×	
58. *Melania insculpta* Meek					×	
59. *Pyrgulifera humerosa* Meek						×
60. *Hydrobia recta* White						×
61. *Viviparus couesi* White						×
62. *Viviparus prudentia* White			×			
63. *Viviparus plicapressus* White				×	×	
64. *Tulotoma thompsoni* White			×		×	
65. *Campeloma vetula* Meek & Hayden	×			×	×	
66. *Campeloma multistriata* Meek & Hayden		×	×			
67. *Campeloma multilineata* Meek & Hayden		×			×?	
68. *Campeloma macrospira* Meek						×
69. *Odontobasis buccinoides* White					×	
70. *Odontobasis? formosa* White				×		
71. *Corydalites fecundum* Scudder			×			

*See remarks under No. 19 on p. 244.

NOTE.—As a rule, those species which, on account of imperfection of the specimens, have not been satisfactorily recognized are not included in this list, as they were in the local lists. An ? following a name, of course indicates a doubt as to its accuracy. Placed in one of the columns with an asterisk, indicates a doubt as to whether the species found at the locality indicated is really the one named in the list.

The double vertical line in the foregoing table may be taken to represent the Rocky Mountains, or the great range that extends northward through Colorado, Wyoming and Montana; the localities or districts represented on its left being east, and those on its right west, of those mountains. An examination of the table will show that this mountain range has no paleontological significance as a geographical boundary between those eastern and western localities of Laramie strata, because the species range across it almost as freely as they do across the space which separates any two or more of the others. Indeed, the great contrast that is presented between the fauna of the brackish-water beds of the Laramie Group in Bear River Valley and that of the great body of the group elsewhere, as now known, is not marked by any now existing physical feature, and what the real cause of that contrast was, yet remains to be discovered. It is evident that the present hypsometric condition of the North American continent has no direct relation to the distribution of species in the strata of the Laramie Group, or in any of the Cretaceous groups.

It is a fact worthy of especial notice that not a single species of all those that have been found in the brackish-water beds of Bear River Valley, with perhaps the exception of a *Physa*, is identical with any that have yet been found in any other Laramie strata; those indicated in the table as thus identified having been obtained from the upper Laramie beds at the Evanston coal-mines, which are of fresh-water origin. Another significant fact is that those species which are thus identified are pulmonate mollusks; the species which differ most widely from other Laramie forms being branchiferous mollusks. The natural inference from this fact is that the modifying conditions which then existed in this part of the continent produced their effect upon that portion of the invertebrate fauna which inhabited the principal waters, leaving the land and palustral fauna comparatively unchanged.

Taking a general view of the species as represented in the foregoing table it will be seen that the palustral pulmonates occur in all the districts indicated, and that land-shells also are not uncommon. These facts, together with the identity of species and types of those mollusks in the various districts, indicate great uniformity throughout the whole Laramie period of such physical conditions as would affect those mollusks. In considering the distribution of the other types represented in the table, namely, those of the branchiferous mollusks, for reasons already given, those of the brackish-water beds of Bear River Valley must be, at least in part, excluded. We find, however, that the *Unionidæ*, *Ceriphasiidæ*, and *Viviparidæ*, among fresh-water types, and the *Ostreidæ*, *Anomiidæ*, *Cyrenidæ*, and *Corbulidæ*, among brackish-water types, are common to all the districts represented, the *Cyrenidæ* being especially numerous in species in Eastern Colorado. Besides these, there are other types belonging to both categories which, so far as is now known, are less widely distributed, but those families just mentioned are sufficient to serve as a basis for some general remarks which are to follow. So far as may be seen from the foregoing table, or from any similar tabular exhibition of species, they may have occurred promiscuously associated in the same layers at any and all of the localities indicated. On the contrary, certain of these types are, as a rule, confined locally to certain layers, which respectively represent the ground of their former habitats; but there is not unfrequently found such an admixture of types in one and the same layer as to show plainly that some of them must have been drifted to the places of their present entombment and association.

It is easy to understand how the light shells of land and palustral gasteropods might, after having been emptied of their decomposed bodies, have been drifted to almost any distance unharmed, and finally have found entombment with the shells of mollusks that lived and died in the very sediments that now inclose them all. But there are cases of equally heterogeneous association which cannot be accounted for in that way. These cases consist of the presence in the same layers of the shells of branchiferous mollusks, both conchifers and gasteropods, belonging to types that are respectively recognized as of brackish and fresh water habitat. It is well known that the shells of fresh-water mollusks are often carried down by the current of rivers and deposited in the sediments of the brackish waters of estuaries along with those of such mollusks as find a congenial habitat there. Where such is the case the drifted shells suffer attrition, the effects of which are readily recognized; the opercula of gasteropods are separated from the shells, and the valves of conchifers are separated from each other. Besides this the sedimentary accumulations of an estuary contain inherent evidence of their character as such aside from that which is afforded by the types of its mollusca; such as accumulation of river silt with its current-worn fresh-water shells, and the peculiar stratification produced by floods and changing currents. Although it has been not uncommon for geologists to speak of the different brackish-water strata of the Laramie Group as "estuary beds," or to refer to them as of estuary origin, I do not know of a single deposit or part of one in any district, or in any of the divisions of the great Laramie Group, to which the foregoing test of its estuary origin can be applied.

Although rivers of greater or less magnitude must necessarily have flowed into the Laramie sea, in no part of the group at any of the numerous localities where I have studied it have I found the character or condition of its strata in any way indicating that they were either influenced or modified by fluvatile influx. On the contrary, its sandstones, and most of its other lithological features, are everywhere of the same general character as those of the Fox Hills Group of Cretaceous strata, which are plainly of marine origin. But notwithstanding this evident uniformity of deposition, a large proportion of the fossiliferous Laramie strata contain a commingling of brackish and fresh-water forms, the condition and association of which show that those of neither category could have been drifted to their present position from a different habitat. For example, in the brackish-water beds of Bear River Valley great numbers of the shells of *Corbicula*, *Corbula*, and *Unio* (two species of the latter genus) are found associated together in the same layers, the majority of the examples of all of which have both their valves together in their natural position. Besides this, none of the numerous associated shells of gasteropods show any evidence of attrition such as they would have received if they had been drifted. These facts indicate that all the mollusks referred to lived contemporaneously in the same waters, and that the sediment upon which they lived is the same as that which now incloses them. It is a well-known fact that some species of *Corbicula* and *Neritina* may live in waters that are nearly or quite fresh, but the presence among those shells of the Bear River strata of *Corbula*, *Membranipora*, and a few scattered oyster-shells seems to make it certain that the waters containing all of them were, at least in some degree, saline. It also seems certain that there was some alternation of the degree of saltness of those waters, because there has been found at least one thin layer there which is composed almost wholly of a small *Ostrea*, with no other associated shells.

Again, at Black Buttes Station there is also evidence of alternation of

saltness in the waters. In one layer *Unio* and *Corbicula* in abundance, the former represented by half a dozen species, are associated together, a very large proportion of all of them having their valves together in natural position, showing that none of them had been drifted; and with these, in the same layer, are associated *Neritina* and *Melania*, which also show no evidence of having been drifted. At the same locality there are certain layers, alternating with other fossiliferous layers, which contain *Ostrea* and *Anomia* alone, and which probably represent the maximum saltness of the waters that prevailed there. There are also other alternating layers, which contain fresh-water types alone, which probably represent the minimum saltness, or perhaps entire freshness of the water that prevailed at that particular place at certain times, and the layers containing a mixture of types probably represent intermediate grades of saltness of those waters. It is remarkable that, with all this variation of their fossil contents, none of the strata present any evidence of littoral or estuary deposition.

While it seems evident that at different times in certain places these Laramie waters alternated from a decidedly salt to a nearly or wholly fresh condition, it seems equally evident that certain species belonging to different types, the representatives of which are now found only in fresh waters, were then capable of living and thriving in waters that contained a considerable degree of saltness. The species referred to belong to the *Unionidæ*, *Cariphasiidæ*, and *Melaniidæ*, the fact of the association of certain species belonging to the first and second of these families with brackish-water forms at Bear River Valley having been already stated; and on previous pages the association of *Melania wyomingensis* and *M. insculpta* with *Ostrea* and *Anomia* has already been noted.

It is a remarkable fact that the species belonging to the three families named, which are found with the brackish-water associates, almost without exception present a greater degree of differentiation than those do which are found in later but purely fresh-water deposits; and also in some cases greater than that which is shown by recent congeneric forms. This fact led me in a former publication* to suggest that the peculiar differentiation that has been attained by our North American *Unionidæ* began under the influence of a certain degree of saltness of the waters in which they lived.

There are many well-known instances of living species of mollusks, belonging to families that are regarded as of distinctively marine habitat, which are found far up from the mouths of certain rivers, inhabiting waters that are wholly and always fresh, to which habitats they seem to have made their way against opposing and, at first, uncongenial conditions. On the other hand it is not to be denied that instances of living mollusks of fresh-water types encroaching upon marine waters are rare; †

* See Bull. U. S. Geol. and Geog. Sur. Terr., vol. iii, p. 623 *et seq.*

† The Baltic, Black, and other *tideless* seas appear to afford the majority of the known instances of the commingling of living fresh-water with brackish or marine forms, and these occur in estuaries whither the fresh-water forms had been carried from their fluviatile habitats by floods or the ever-present pressure of the river-flow. Fresh-water mollusks in saline waters are not, however, always there by compulsion, because upon the shores of Great Salt Lake, as noted by Mr. Gilbert and myself, a species of *Physa* and one of *Limnæa*, both of which are common in the fresh waters of that region, have been found inhabiting pools of water that was found to be much too salt to drink; and at the Hot Sulphur Springs in Middle Park, Colorado, I found the same species in water strongly charged with sulphur. In both these cases, however, the adult size of the individuals was considerably less than that of those found in fresh waters. The presence of tides, even in waters that are always fresh, seems to be quite uncongenial to most if not all species of fresh-water mollusks, and it is probably this condition that aids in preventing the commingling of fresh and brackish water forms.

and in all such cases their changed habitat seems to have been, at least in some degree, forced upon them by environing conditions; and the individual condition of those mollusks, when compared with that of the same species in fresh waters, shows evidence of the uncongeniality of their changed habitat. It seems impossible, however, to account for the commingling of types which we find in the Laramie strata in any way except by assuming that they lived together in the same waters; and their individual condition in all cases suggests that they all thrived equally. Furthermore, it seems to be unquestionable that the waters in which the greater part of this commingling of types took place possessed a considerable degree of saltness, and that the great Laramie sea was essentially one of brackish waters.

While very much remains to be known concerning the geological structure of the North American continent, the great array of facts that have been already accumulated enables us to draw from them many legitimate conclusions concerning the former physical conditions of certain portions of it, and to begin with some confidence to arrange them as materials toward its physical history. The following remarks upon this subject are presented as supplementary to the foregoing report, but they are based largely upon facts that have been previously accumulated and published by various authors. They relate almost wholly to the Mesozoic and Cenozoic Groups, and to the corresponding epochs in the geological history of the continent. They are necessarily general in their character, and are intended to apply especially to that portion of the national domain which may in a general way be designated as lying north of north latitude 37° and between west longitude 95° and 113°.

East of longitude 95°, North America is mainly occupied by Paleozoic and Archæan rocks, as is also a large area which extends northward and southward through Western North America; the eastern border of the latter area being adjacent to the region here discussed, and not far from the one hundred and thirteenth meridian of west longitude. These two great areas are taken to represent approximately the outline and extent of the principal portions of the present North American continent that were above the level of the sea at the close of paleozoic time. A broad expanse of Mesozoic sea then stretched between these two continental factors, which were finally united by a general continental elevation and the consequent recedence of the sea. This elevation was not, properly speaking, catastrophal, but gradual and oscillatory. That intercontinental Mesozoic sea was narrower during the Jura-Trias period than it was afterward, but it was always shallow as is shown by the lithological character of the strata of all the Mesozoic formations; and as these aggregate a great thickness there was, of course, for a long time, and over a very large part of the space which it occupied, a gradual subsidence of the bottom which allowed the successive deposition of shallow-water formations. The following facts prove the occurrence of oscillations of land surface and sea-bottom by which from time to time the eastern border of the Mesozoic sea was shifted and the whole finally displaced.

In Western Iowa, Eastern Nebraska, and Eastern Kansas the Cretaceous strata are known to rest directly upon Carboniferous strata, the Jura-Trias being absent. These last-named strata, however, are in full force where the Mesozoic rocks are turned up against the eastern flanks of the Rocky Mountains and Black Hills, as well as farther westward. Their eastern border is certainly somewhere in the great plains beneath later Mesozoic strata and the prevailing surface *débris*, but its location is not even approximately known. Cretaceous strata, continuous with those of the West, are known to have been deposited as far eastward as

within fifty or sixty miles of the Mississippi River in Northern Iowa and Southern Minnesota, southward from which region their eastern border gradually recedes to the westward nearly as far as Central Kansas. In the northeastern region just named it is the attenuated strata of the Fort Benton and Niobrara Groups that are found, and these rest directly upon the Paleozoic rocks, the Dakota Group being absent there. In Western Iowa and Eastern Nebraska the strata of the Dakota Group are found to rest upon the Paleozoic rocks, the former extending farther eastward then than any other Cretaceous strata; but the eastern border of the Fort Benton and Niobrara Groups are there not very far to the westward. The eastern border of the Fort Pierre and Fox Hills Groups or the later Cretaceous is still farther westward, but its position is hidden by the later formations and the prevailing *débris* of the plains.

From the foregoing facts the following inferences may be legitimately drawn. During the period represented by those Western rocks which have received the designation of Jura-Trias (and apparently during a portion of the Permian period also), the western shore-line of the eastern or principal continental factor extended so far westward that the eastern border of the deposits of the period referred to reached no farther eastward than along some line now far out on the great plains but the location of which is not known. It is now covered from possible discovery by superimposed Mesozoic strata and the prevailing surface *débris*. At the close of the Jurassic period a subsidence took place which carried the deposits of the Dakota Group nearly as far eastward as Central Iowa. Still later, continued subsidence, but of more limited extent, to the southeastward caused the deposition of Fort Benton and Niobrara strata still farther eastward, in Northern Iowa and Southern Minnesota. At or before the close of the Niobrara epoch, the elevation of the western portion of the eastern or principal continental factor was resumed, and apparently continued without further interruption by any other subsidence sufficient to carry any of the recovered or added land surface again beneath the level of the sea; although portions of the area which the inter-continental Mesozoic sea had covered were afterward occupied by great bodies of brackish and fresh waters. The eastern border of the later Cretaceous deposits was thus carried westward where its place is now covered like that of the earlier border of the Jura-Trias deposits, but not so deeply.

The eastern border of the Laramie Group is hidden in the same manner, but there is yet no evidence that it is anywhere overlapped by any subsequent *marine* deposit, although it is known to have received upon it in several places different groups of fresh-water strata. Perhaps no fact in the physical history of North America is better established than that the elevation of the Rocky Mountains, as such, is of later date than that of the Laramie Group, but the foregoing facts show that both oscillatory movements and general continental elevation took place before the beginning of those movements which resulted in the elevation of those mountains. Besides the oscillations of surface which have already been mentioned, there are indications that other similar movements occurred elsewhere within the same limits of time; such, for example, as the unconformity of the Laramie strata upon those of the Fox Hills Group in Middle Park, reported by Mr. Marvine; the unconformity in some places of the Jura-Trias upon rocks older than the Carboniferous, &c.

But leaving now the subject of the elevation and subsidence of land surface to be resumed further on, the prevailing physical conditions of what is now Western North America may now be considered. No fresh-water deposits of any kind have yet been discovered in any of the Paleo-

zoic rocks of North America, unless the coal of the Carboniferous age may be regarded as such; but even in that case the elevation of the land upon which it was formed could have been only barely above the sea-level, because the conformity of the coal-beds with the strata above and below them is never broken, and the latter strata contain marine fossils. Therefore, for our present purpose, all the Paleozoic strata may be regarded as of marine origin. As a rule, also, all the Mesozoic strata, from the Jura-Trias to the Fox Hills Group inclusive, are, by the character of their fossils, known to be of marine origin, although at a few localities in some of the strata of each period fresh-water mollusca have been discovered. These exceptions, no doubt, indicate the proximity of then existing shores rather than the prevalence of any such bodies of either brackish or fresh water as afterward covered wide areas in the same region.

Resting directly upon the strata of the Fox Hills Group are those of the Laramie Group, the latter, as already shown, having been at least in part deposited continuously with the former. The geographical boundaries of the great Laramie formation are not known, but its area embraces many thousand square miles, for it is known to extend from Southern Colorado and Utah northward beyond the northern boundary of the United States; and from the Wasatch Mountains, eastward far out on to the great plains. It reaches a maximum thickness of about 4,000 feet, and its general lithological characteristics are similar to those of the Fox Hills Group, a known marine formation. Its fauna, however, has been shown to be largely of brackish and partly of fresh water origin, and not marine. Furthermore, the brackish-water species are distributed throughout its entire thickness and its whole geographical extent. These facts, together with the absence from all the strata yet examined of any true estuary characters, show that the Laramie Group was deposited in a great brackish-water sea. This being the case, it must have received its peculiar character, as well as its boundaries, by having been separated from the great open sea by an encircling elevation of land; the continuity of shore-line having been completed by elevations connecting the two great continental factors at the northern and southern portions of the inter-continental Mesozoic sea. Whether the brackish saltness of the Laramie sea was sustained throughout the period by limited communication of its waters with those of the great open sea, or whether such communication was entirely cut off, and the supply of salt above that which was originally retained of its marine saltness came by adjacent continental drainage in amount sufficient to balance the waste by overflow, can probably never be known, but the latter seems probable.* If the former condition existed, one of the places of communication was no doubt at the southeastern border of the Laramie sea, and some fortunate exposure of strata in the region between Western Kansas and the Gulf of Mexico may yet reveal the true relations of the Laramie Group with the Cretaceous and Eocene deposits of the Gulf border. If tide-level communication between the Laramie sea and the great open sea was entirely cut off, as there is much reason to believe it was, the question of such relationship or contemporaneousness of deposition must ever remain an open one.

It is evident that the movements which caused the inclosure of the

* The frequent presence of fresh-water forms in the strata of this group, from its base to top, such as *Unio*, *Melania*, *Viviparus*, *Campeloma*, *Goniobasis*, &c., are suggestive of the non-existence of tides in its waters, such as would have existed if they had communicated freely with the open sea, for the living representatives of these mollusks do not find a congenial habitat in tide-water, even if it be fresh.

Laramie sea did not materially interrupt the continuity of sedimentation within at least a very large part of its area, although the effects of those physical changes were such as to cause a total change in at least the molluscan fauna. The wide geographical distribution and great vertical range of many of the molluscan species of the Laramie Group, and the great uniformity of its lithological characters, show that the period was one of comparative quiet within the region which was occupied by its waters. There were, however, some comparatively slight oscillations of surface or sea-bottom which caused local unconformity of strata, but these cases are so limited in extent, so far as they are known, that at no great distance away from each the strata, which evidently correspond with the displaced ones, show no evidence of disturbance. An example of such an oscillation is illustrated by the unconformity among Laramie strata in Bitter Creek Valley, which has already been discussed.

While there is evidence that this general quiet was preserved, not only through the Laramie period, but that it was continued into the Tertiary epochs which immediately followed, it is true that at or near the close of the Laramie period in the region which now embraces a part of Bear River Valley, and there covered in part by the western border of the Laramie sea, there was an extensive displacement of the Laramie and older strata, which brought the subsequently-formed Tertiary deposits unconformably upon them. These facts have been briefly discussed on preceding pages, but that region, with its important geological and paleontological features, I have yet only slightly investigated. It has been shown on preceding pages that notwithstanding these and doubtless other disturbances which occurred elsewhere at several localities, in the great Green River Basin and in the valleys of White and Yampa Rivers the strata show satisfactory evidence that there was continuous sedimentation from the close of the Laramie period to the beginning of, and during the Wasatch epoch. Besides this, the continuity of sedimentation from the epoch of the Wasatch to that of the Bridger Group inclusive is a fact that, so far as I am aware, is disputed by no one. Admitting these facts, together with the conclusions that have been drawn on preceding pages, we have in these Western strata an unbroken geological record, extending, at least, from earlier Mesozoic far into Tertiary time; the apparent paleontological breaks in that record being really only faunal displacements, which were caused by radical changes of environment, notably the removal or variation of the saltness of the waters that were consequent upon the different physical changes which took place in the progress of the evolution of the continent.

The already accumulated geological facts show that the general continental elevation was continued after the Laramie period much in the same manner that it progressed up to that time (for the Rocky Mountains were not yet elevated), still inclosing large bodies of water, but which were no longer salt. The elevation of the Laramie sea was doubtless, at most, only slightly above that of the great open sea, but the elevation of its former bed was no doubt considerably increased during its successive occupancy in part by the Wasatch, Green River, and Bridger lakes. There must, however, have been a gradual subsidence of the bottom of each of these great bodies of fresh water, which permitted the accumulation of the immense thickness of their strata which now remain, besides that which has been removed by erosion. Free drainage of overflow into the open sea must also have been maintained during these later epochs, which kept their waters fresh, but which evidently did not exist during the Laramie period; but it is not my purpose to discuss these questions in this report. It is proper, however, to present very

briefly some of the facts that bear upon the physical conditions which prevailed during the Laramie period within the region that was occupied by its waters.

After the facts presented and the remarks made upon preceding pages of this report it is almost superfluous to say that the great Laramie Group is regarded as having been deposited in a brackish-water sea, which, for extent and character, has no existing parallel. There are, however, certain characteristics of fossil fauna and strata that indicate some very peculiar conditions of that sea then existing which deserve much investigation, but which, for obvious reasons, can receive only brief consideration here. First, it is evident that at all times its waters had comparatively little depth, and that in many places it was repeatedly very shallow; and, furthermore, that the great thickness of the group, amounting to a maximum of 4,000 feet, was accumulated by a gradual subsidence of the bottom. As a rule, its molluscan fauna was composed of brackish-water types, but often, and in many places, the waters were so far freshened as to give congenial habitat to fresh-water forms. Judging from the characteristics of existing land-locked seas, it is difficult to understand clearly how fresh and brackish waters could have existed in one and the same sea in the absence of or at a distance from the mouths of tributary rivers. But the character of the deposits of the Laramie sea, as well as its molluscan fauna, warrants the suggestion that very large portions of its area were at different times and in different places in the condition of marshes, which were only slightly raised above the general water level, upon which fresh waters from rains accumulated and gave congenial habitat to such members of the molluscan fauna of the period as would preferably avoid the brackish waters. This view is supported by the occasional presence of land-shells among those of branchiferous mollusks, the more common occurrence of palustral shells, the occurrence of deciduous leaves and other fragments of vegetation, all in the same or associated strata; and also the presence of numerous beds of lignite throughout the group. It is also supported by the fact that the fossil mollusca are found not uniformly distributed throughout the group either vertically or geographically, but to occupy very small, distantly-separated areas, which are not only locally restricted, but within which areas the vertical range of the different species is limited. Admitting that such conditions prevailed, it is easy to understand how it may have happened that certain layers, containing the remains of mollusca, which could have flourished only in salt or brackish waters, are found to alternate in close succession with those containing fresh-water species. The conditions thus indicated would also have brought the brackish and fresh water habitats of those mollusca into such juxtaposition that they must have frequently encroached upon each other. This frequent encroachment, or mingling of habitats, and no doubt the frequent impracticability of retreat, would have had a tendency to inure at least a portion of the mollusks of each to an existence in the other. It is evident that many of the species were capable of such interchange of habitat without disadvantage; and that some of the species whose living representatives are regarded as strictly fresh-water forms may have then lived in part in brackish waters, such as *Melania*, *Unio*, &c., has already been suggested.

In the foregoing report I have purposely avoided an expression of opinion as to the true geological age of the Laramie Group, because, notwithstanding the positive opinions that have been expressed by others upon that subject, I regard it as still an open question. All paleontologists agree that the Cretaceous period extended at least to the close of the Fox Hills epoch, and that the Tertiary period began at least as early

as the beginning of the Wasatch epoch; and the question is whether the Cretaceous period closed with the close of the Fox Hills epoch or with that of the Laramie period. The question might be extended so as to embrace the inquiry whether the true chronological division between Cretaceous and Tertiary did not really occur within the Laramie period; but this, while not unreasonable, would perhaps be inconvenient and unprofitable. The claim that Cretaceous types of vertebrates are found in even the higher strata of the Laramie Group is freely conceded, and I have no occasion to question the reference that has been made of its fossil plants, even those of the lowest strata, to Tertiary types. The invertebrate fossils of the group itself, as I have elsewhere shown, are silent upon this subject, because the types are either unique, are known to exist in both Mesozoic and Tertiary strata, or pertain to living as well as fossil forms. Every species found in the Laramie Group is no doubt extinct, but the types have collectively an aspect so modern that one almost instinctively regards them as Tertiary; and yet some of these types are now known to have existed in the Cretaceous and even in the Jurassic period.

In view of the conflicting and silent character respectively of these paleontological oracles the following suggestions are offered: It is a well-known fact that we have in North America no strata which are, according to European standards, equivalent with the Lower Cretaceous of Europe, but that all North American strata of the Cretaceous period are equivalent with those of the Upper Cretaceous of that part of the world. That the Fox Hills Group is of Upper Cretaceous age no one disputes, the only question being as to its place in the series. A comparison of its fossil invertebrate types with those of the European Cretaceous indicates that it is at least as late as, if not later than, the latest known Cretaceous strata in Europe. If, therefore, that parallelism is correctly drawn, and the Laramie Group is of Cretaceous age, we have represented in America a great and important period of that age which is yet unknown in any other part of the world. Besides this, we may reasonably conclude that the Fox Hills Group of the west is equivalent with the Upper Cretaceous strata of the Atlantic and Gulf coasts, between which and the Eocene Tertiary of those regions there is no known equivalent of the Laramie Group.

If paleontologists should finally agree upon regarding the Laramie Group as of Cretaceous age, it must be because of the continuance of certain vertebrate Cretaceous types to the close of that period, and the presence of mammalian Tertiary types in the strata immediately following; but the following facts, in addition to those which have been already stated, should be carefully considered before any such agreement is made.

With rare and obscure exceptions no mammalian remains are known in North American strata of earlier date than that of those which were deposited immediately after the close of the Laramie period and upon its strata. Immediately from and after the close of the Laramie period their abundant remains in the fresh-water Tertiaries of the West show that highly organized mammals existed in great variety and abundance; all of which may be properly regarded as constituents of a Tertiary fauna, and many of which are, by accepted standards, of distinctively Tertiary types. If the presence of these forms in the strata referred to, and their absence from the Laramie strata immediately beneath them, together with the presence of Dinosaurians there, be held to prove the Tertiary age of the former strata, then was the Tertiary period ushered in with most unnatural suddenness. Sedimentation was, at least in part, unbroken between the Laramie Group and the strata which contain the mammalian remains referred to, so that the local conditions of the ori-

gin of all of them were substantially the same, and yet, so far as any accumulated evidence shows, those mammalia were not preceded in the Laramie period by any related forms. Such suddenness of introduction makes it almost certain that it was caused by the removal of some physical barrier, so that ground which was before potentially Tertiary became so by actual faunal occupancy. In other words, it seems certain that those Tertiary mammalian types were evolved in some other region before the close of the Laramie period, where they existed contemporaneously with at least the later Laramie Dinosaurians of Cretaceous types, and that the barrier which separated the faunæ was removed by some one of the various movements connected with the evolution of the continent. The climate and other physical conditions which were essential to the existence of the Dinosaurians of the Laramie period having evidently been continued into the Tertiary epochs that are represented by the Wasatch, Green River, and Bridger Groups, they might doubtless have continued their existence through those epochs as well as through the Laramie period, but for the irruption of the mammalian horde, to which they probably soon succumbed in an unequal struggle for existence.

CATALOGUES OF FOSSILS.

The following lists of fossils are those of collections which have from time to time been sent to the office of the survey from different places in the western part of the national domain by persons who are not, or were not then, officially connected with the survey. They are introduced here partly to show the association of the species, a part of which were originally described in publications of the survey, and partly to show the geographical distribution of species and types, especially those of Cretaceous age, in the strata of North America.

LIST OF CRETACEOUS FOSSILS SENT BY MR. ARTHUR LAKES FROM BEAR CREEK VALLEY, NEAR MORRISON, COLORADO.

Fox Hills Group.

1. *Pteria linguiformis* Evans & Shumard; 750 feet below the coal.*
2. *Pteria (Pseudoptera) fibrosa* Meek & Hayden; 750 feet below the coal.
3. *Inoceramus oblongus* Meek; 750 feet below the coal.
4. *Cardium speciosum* Meek & Hayden; 200 feet below the coal.
5. *Tellina scitula* Meek & Hayden; 200 feet below the coal.
6. *Mactra holmesi* Meek, sp.; 750 feet below the coal. This is the species which was originally described as *Cyrena?* and supposed to have belonged in Laramie strata.
7. *Pachymya herseyi* White; 200 feet below the coal.
8. *Dentalium gracile* Hall & Meek; 200 feet below the coal.
9. *Lunatia occidentalis* Meek & Hayden; 750 feet below the coal.
10. *Baculites ovatus* Say; 750 feet below the coal.
11. *Scaphites nodosus* Owen; 750 feet below the coal.
12. *Scaphites mandanensis* Morton?; 750 feet below the coal. This is recognized as belonging to the same species as the fragment which was found associated with *Mactra holmesi* at the original locality on Ralston Creek. (See remarks under No. 6 of this list.)
13. *Placenticeras placenta* Dekay (var.); 750 feet below the coal.

* The coal referred to is within and near the base of the Laramie Group, but all the fossils of the list are found in unmistakable Cretaceous strata.

Colorado Group.

14. *Ostrea congesta* Conrad. From limestone layers near the top of the group.
15. *Inoceramus deformis* Meek. From limestone layers near the top of the group.
16. *Inoceramus problematicus* Schlot. From limestone layers near the top of the group.

LIST OF FOSSILS SENT BY MR L. C. WOOSTER FROM THE VICINITY OF GREELEY, COLORADO.

Fox Hills Group.

1. *Pteria* (*Oxytoma*) *nebrascana* Evans & Shumard. Valley of the Cache à la Poudre.
2. *Pachymya? herseyi* White. Mouth of the St. Vrains. It is described and figured in another part of this volume.
3. *Nucula planimarginata* Meek & Hayden. Valley of the Cache à la Poudre.
4. *Tancredia americana* Meek & Hayden. Valley of the Cache à la Poudre.
5. *Cardinum speciosum* Meek & Hayden. Valley of the Cache à la Poudre.
6. *Tellina scitula* Meek & Hayden. Valley of the Cache à la Poudre.
7. *Mactra* (*Cymbophora*) *warrenana* Meek & Hayden. Valley of the Cache à la Poudre.
8. *Dentalium gracile* Hall & Meek. Valley of the Cache à la Poudre.
9. *Actæon woosteri* White. Valley of the Cache à la Poudre.
10. *Lunatia moreauensis* Meek & Hayden? Valley of the Cache à la Poudre.
11. *Fasciolaria* (*Piestocheilus*) *culbertsoni* Meek & Hayden. Valley of the Cache à la Poudre.

Laramie Group.

12. *Corbula perundata* Meek & Hayden. Valley of Crow Creek.
13. *Corbicula* (*Leptesthes*) *fracta* Meek. Valley of Crow Creek.

LIST OF CRETACEOUS FOSSILS SENT BY MR. J. C. HERSEY FROM COLORADO.

Fox Hills Group.

1. *Pteria* (*Oxytoma*) *nebrascana* Evans & Shumard. Valley of the Cache à la Poudre.
2. *Inoceramus barabini* Morton. Monument Creek.
3. *Pachymya herseyi* White. Valley of the Cache à la Poudre. Described and figured in another part of this volume.
4. *Nucula cancellata* Meek & Hayden. Valley of the Cache à la Poudre.
5. *Veniella humilis* Meek & Hayden. Valley of the Cache à la Poudre.
6. *Tancredia americana* Meek & Hayden. Valley of the Cache à la Poudre.
7. *Tancredia? cœlionotus* White. Valley of the Cache à la Poudre. It is described and figured in another part of this volume.

8. *Cardium speciosum* Meek & Hayden. Valley of the Cache à la Poudre.
9. *Tellina scitula* Meek & Hayden. Valley of the Cache à la Poudre.
10. *Mactra* (*Cymbophora*) *warrenana* Meek & Hayden. Valley of the Cache à la Poudre.
11. *Dentalium gracile* Meek & Hayden. Valley of the Cache à la Poudre.
12. *Lunatia moreauensis* Meek & Hayden. Valley of the Cache à la Poudre.

Colorado Group.

13. *Gryphæa pitcheri* Morton? Valley of the Cache à la Poudre above Fort Collins. This seems to belong to this species, but it is, so far as I am aware, the most northerly point at which an example of it has been discovered.
14. *Inoceramus problematicus* Schlotheim. Spring Cañon, sixteen miles west of Greeley, Colo.
15. *Inoceramus deformis* Meek. Spring Cañon, sixteen miles west of Greeley, Colo.

LIST OF CRETACEOUS FOSSILS SENT BY CAPT. E. L. BERTHOND, FROM COLORADO.

Fox Hills Group.

1. *Inoceramus oblongus* Meek. Fossil Creek, 16 miles west of Greeley, Colo.
2. *Nucula planimarginata* Meek & Hayden. Near Golden, Colo.
3. *Nucula cancellata* Meek & Hayden. Near Golden, Colo.
4. *Baculites ovatus* Say. Fossil Creek, 16 miles west of Greeley, Colo.

Colorado Group.

5. *Ostrea congesta* Conrad. Bear Creek Valley, near Morrison, Colo.
6. *Inoceramus deformis* Meek. Bear Creek Valley, near Morrison, Colo.

LIST OF CRETACEOUS FOSSILS SENT BY PROF. O. H. ST. JOHN, FROM NEAR CIMARRON, NEW MEXICO, FROM STRATA REFERRED TO THE FOX HILLS GROUP.

1. *Caryophyllia johannis* White. Described and figured in another part of this volume.
2. *Ostrea congesta* Conrad? This is a small oyster attached to some fragments of an *Inoceramus* resembling those of *I. deformis* or *I. erectus* Meek. It may not belong to this species, but like the one found attached to *I. erectus* in Fox Hills strata, at Coalville, Utah, it is difficult to say how it differs.
3. *Ostrea* ———. An undetermined species.
4. *Anomia* ———. An undetermined species.
5. *Camptonectes* ———. An undetermined species.
6. *Pteria linguiformis* Evans & Shumard.
7. *Inoceramus barabini* Morton.
8. *Inoceramus vanuxemi* Meek & Hayden.
9. *Inoceramus erectus* Meek? Mere fragments, with *Ostrea congesta?* attached. (See remarks under No. 2.)
10. *Crassatella* (*Pachythærus*) *cimarronensis* White. It is described and figured in another part of this volume.

11. *Trapizium.* Undetermined species.
12. *Idonearca shumardi* Meek & Hayden? Examples all very small.
13. *Callista pellucida* Meek & Hayden.
14. *Teredo?* Separated tubes only.
15. *Anisomyon alveolus* Meek & Hayden.
16. *Margarita* ———. Undetermined species. Perhaps new.
17. *Lunatia* ———. Undetermined species.
18. *Turritella* ———. Undetermined species.
19. *Aporrhais biangulata* Meek & Hayden.
20. *Spironema* ———. Undetermined species. Perhaps new.
21. *Pyramidella* ———. Undetermined species.
22. *Turbonilla* (*Chemnitzia?*) ———. Undetermined species.
23. *Fasciolaria* (*Piestocheilus*) ———. Undetermined species.
24. *Baculites ovatus* Say.
25. *Scaphites nodosus* Owen?
26. *Placeniticeras placenta* Dekay.
27. *Serpula* ———. Undetermined species.
28. Undetermined Crustacean. Probably a Brachyuran.

The specimens of this collection have had their specific and other characters much obscured by compression, and by calcareous encrustation.

LIST OF CRETACEOUS FOSSILS SENT BY PROF. B. F. MUDGE, FROM DENNISON, TEXAS.

1. *Ostrea quadriplicata* Shumard.
2. *Ostrea* (*Alectryonia*) *bellaplicata* Shumard.
3. *Gryphæa pitcheri* Morton.
4. *Neithea texana* Rœmer.
5. *Trigonia emoryi* Conrad.
6. *Turritella* ———. Undetermined species.
7. *Auchura* (*Drepanocheilus*) *mudgeanus* White. This species was found in the form of natural casts, together with those of several other undetermined species, in a mass of red hematite. The mass also contained partial casts of two or three of the species of this list, showing that the hematits came from the same formation. It is described and figured in another part of this volume.

LIST OF CRETACEOUS FOSSILS SENT BY MR. G. W. MARNOCH, FROM NEAR HELOTES, BEXAR COUNTY, TEXAS.

1. *Orbitulites texanus* Rœmer.*
2. *Astrocœnia sancta-sabæ* Rœmer.
3. *Toxaster texanus* Rœmer.
4. *Toxaster elegans* Shumard.
5. *Diadema texanum* Rœmer.
6. *Cyphosoma texana* Rœmer.
7. *Cidaris hemigranosus* Shumard.
8. *Hippurites texanus* Rœmer.
9. *Radiolites austinensis* Rœmer.
10. *Terebratula wacoensis* Rœmer.
11. *Ostrea subspatula* Lyell & Sowerby.
12. *Ostrea congesta* Conrad.
13. *Ostrea* (*Alectryonia*) *carinata* Lamarck?

*The nomenclature of the respective authors is here used without any attempt at rectification.

14. *Gryphæa pitcheri* Morton. Besides forms like those figured by Morton, Rœmer, and other authors, there are in this collection some large examples that are doubtless only a variety of *G. pitcheri*. The radiating prominence common to the larger valve of most of the typical examples is in this variety very prominent, angular, and roughened by occasional projecting or vaulted laminæ.
15. *Exogyra arietina* Rœmer.
16. *Exogyra texana* Rœmer.
17. *Exogyra ponderosa* Rœmer.
18. *Exogyra costata* Say.
19. *Neithea texana* Rœmer.
20. *Inoceramus* ———. Undetermined species.
21. *Lima leonensis* Conrad.
22. *Trigonia emoryi* Conrad.
23. *Protocardia texana* Conrad.
24. *Anatina* ———. Undetermined species.
25. *Liopistha* (*Cymella*) ———. Undetermined species.
26. *Cucullea terminalis* Conrad.
27. *Gyrodes* ———. Undetermined species.
28. *Pleurotomaria* ———. Undetermined species.
29. *Turritella marnochi*. White. Described and figured in another part of this volume.
30. *Turritella* ———. Undetermined species.
31. *Nerinæa* ———. Undetermined species.
32. *Turbonilla?* ———. Undetermined species.
33. *Ammonites peruvianus* Von Buch.
34. *Ammonites flaccidicosta* Rœmer.
35. *Ammonites woolgari* Mantell.?
36. *Turrilites brazosensis* Rœmer.

LIST OF CRETACEOUS FOSSILS SENT BY D. H. WALKER TO THE SMITHSONIAN INSTITUTION, FROM NEAR SALADO, BELL COUNTY, TEXAS.

1. *Astrocoenia sancta-sabæ* Rœmer.
2. *Toxaster texana* Rœmer.
3. *Toxaster elegans* Shumard.
4. *Diadema texanum* Rœmer.
5. *Cyphosoma texanum* Rœmer.
6. *Hippurites texanus* Rœmer.
7. *Radiolites austinensis* Rœmer.
8. *Terebratula wacoensis* Rœmer.
9. *Ostrea congesta* Conrad.
10. *Ostrea* ———. A large undetermined species.
11. *Ostrea* (*Alectryonia*) *subovata* Shumard.? This appears to be identical with Dr. Shumard's species as figured and described in Marcy's Exploration of the Red River of Louisiana, but the description is brief and the figure poor.
12. *Ostrea* (*Alectryonia*) *carinata* Lamarck? This is the species which has been usually referred to *O. carinata* Lamk., and the same as No. 13 of the preceding list, but it is probably specifically distinct.
13. *Gryphæa pitcheri* Morton. The specimens, as usual, present considerable variety; this being the most variable species of the genus known.
14. *Exogyra walkeri* White. Described and figured in another part of this volume.
15. *Exogyra læviuscula* Rœmer.

16. *Exogyra ponderosa* Rœmer.
17. *Exogyra texana* Rœmer.
18. *Exogyra arietina* Rœmer.
19. *Spondylus ?* ———. This is apparently a *Spondylus*. The few examples of it in the collection are attached at full length to other fossil shells. It is about two and a half centimeters long, and the surface marked by numerous fine radiating lines.
20. *Modiola sancta sabæ* Rœmer.*
21. *Neithea duplicata* Rœmer.
22. *Neithea texana* Rœmer.
23. *Pinna* ———. Undetermined species.
24. *Inoceramus deformis* Meek ?
25. *Inoceramus* ———. A large broad species.
26. *Lima* ———. A robust spinulose species.
27. *Trigonia emoryi* Conrad.
28. *Tapes hilgardi* Shumard.
29. *Protocardia texana* Conrad.
30. *Arcopagia texana* Rœmer.
31. *Anatina ?* ———. Undetermined species.
32. *Liopistha sancta-sabæ* Rœmer sp.
33. *Corymya* ———. This species resembles an elongate *Glycymeris*, but it has the internal rib radiating from the beak of each valve, which characterizes *Corymya*. The collection contains only one example, an internal cast. The species is undetermined.
34. *Pachymya austinensis* Shumard.
35. *Actæonella dolium* Rœmer.
36. *Spiractæon* ———. Undetermined species.
37. *Pleurotomaria ?* ———. The examples are rather large, and being imperfect their generic characters cannot be clearly determined, but they appear to possess the general characteristics of *Pleurotomaria*.
38. *Lunatia collina* Conrad sp.
39. *Lunatia pedernalis* Rœmer sp.
40. *Nautilus elegans* Sowerby.
41. *Nautilus* ———. Undetermined species. A cast only.
42. *Ammonites flaccidicosta* Rœmer.
43. *Ammonites leonensis* Conrad.
44. *Ammonites peruvianus* Von Buch.
45. *Placenticeras placenta* DeKay.
46. *Turrilites brazosensis* Rœmer.
47. *Serpula intrica* White.
48. *Serpula* ———. A large undetermined species.

Taking a general view of the Cretaceous faunæ of the different regions of Western North America, we find that there is a marked difference between certain of the widely separated regions. For example, the fauna of the Texas region, including portions of the adjacent Territories; that of the Pacific coast, especially California, and that of the Upper Missouri River region, are each found to possess well-marked fanual peculiarities. Not only are almost all the species in each region different from those of any of the others, but several of the higher groups, as well as peculiar types, are found to be restricted to each. The differences of this character are as great, if not greater, between the Texas and Upper Missouri River regions as they are between either of these and that of

*As a rule I adopt the nomenclature of the various authors in this list without any attempt at rectification.

the Pacific coast; and yet, for reasons suggested in the following remarks, it is probable we shall be able to correlate the strata of the Upper Missouri River region with those of the Texas region more directly than with those of the Pacific coast. No doubt the Cretaceous sea connected the Texas and Upper Missouri River regions directly, without the interposition of land surface, great or small, and the strata of Cretaceous age may now be traced nearly or quite continuously from one region to the other; while it is certain that one or more continental factors were interposed between these, together with their intermediate region, and the waters which then covered what is now the Pacific coast region. It is in the intermediate region between that of Texas and the Upper Missouri River that my labors for 1877 were prosecuted, and a part of the collections made by others and recorded in the immediately preceding lists were obtained in the same intermediate region. Besides these, collections have been made by various parties of the United States surveys in the same and adjacent regions, all of which show a commingling of the forms which are among those that are respectively peculiar to each of the separated regions. It is expected that this subject will receive especial attention in future reports, but the following prominent facts may be noted here, the comparisons being mostly between portions of the Texas and Upper Missouri River regions, respectively.

Collections from the Cretaceous rocks of Texas show a remarkable profusion of the Ostreidæ, especially of the genera *Gryphæa* and *Exogyra*. So far as I am aware, no example of *Gryphæa* has been found in any Cretaceous strata of the West north of latitude 41°; nor any example of *Exogyra* north of latitude 38°; these parallels being used for convenience as approximate boundaries. While it is possible they do exist north of those boundaries respectively, it is very certain they are exceedingly rare there. These remarks apply only to Cretaceous rocks, for *Gryphæa* is well known to exist in Jurassic rocks much farther north. Southward from those boundaries respectively, the two genera named are well represented, but they apparently reach their greatest abundance in Texas, in the rocks of which region at least six species of *Exogyra* are found.

Again, the Hippuritidæ are common in the Cretaceous rocks of Texas, but I am not aware that an example of any species of the family has ever been found north of latitude 35°; and the same may be said of the genus *Nerinæa*, two or three species of which are found in Texas, but none farther northward. Echinoderms are very rare in the Cretaceous rocks of North America, except in those of Texas, where they are not uncommon, but hitherto none but the Echinoidea have been discovered, so far as I am aware. Northward from that region only one representative of the Crinoidea, one of the Asteroidea, and one of the Echinoidea have been found. Besides these differences, there are many genera and some families well represented in one region that are not known or only slightly represented in the other.

Aside from these faunal differences between different regions of North America, which seem not to have been due to separation by then existing land barriers, nor to mere local conditions, there are some regional differences that do seem to have been due to local conditions connected with proximity of extended coasts; such, for example, as those which appear in the fauna of the Coalville series of Cretaceous strata. Furthermore, the fauna of all these regions, taken collectively, compared with rocks of admitted equivalency of age in other parts of the world, present differences that cannot be accounted for by any of the causes suggested. These differences are no doubt due in part to the more or less remote effects of conditions which governed the distribution of species, but

doubtless in large part also to the condition of the bottom of the seas which covered the area that now constitutes the regions here discussed. It is sufficient in this connection to point out a single fact bearing upon this subject. The strata of the Cretaceous formations of the West are almost all and everywhere sandstones or sandy shales, and therefore the whole sea bottom in those regions must have been almost always and everywhere covered with sand. Our knowledge of the faunæ of existing seas tells us that the continued prevalence of this condition could not but have exerted a material effect upon the Cretaceous fauna of this portion of North America. Notwithstanding these faunal differences in the strata of the different regions, it is believed that they are all respectively synchronous or nearly so; and being so, it is expected that the classification adopted by Hayden and Meek for those of the Upper Missouri River region may be appropriately applied to the greater part if not all the Cretaceous strata of Western North America.

CONTRIBUTIONS TO INVERTEBRATE PALEONTOLOGY, NO. 1*: CRETACEOUS FOSSILS OF THE WESTERN STATES AND TERRITORIES.

By C. A. White, M. D.

The materials which form the subject of this contribution have been derived from various sources, and the fossils illustrated in the accompanying plates have been obtained from Cretaceous strata of widely separated districts of the national domain. A part of them were collected by different parties of the United States Geological and Geographical Survey of the Territories in Colorado, Wyoming, and Utah; a part by Mr. D. H. Walker at and in the vicinity of Salado, Bell County, Texas; a part by Mr. G. W. Marnoch at and in the vicinity of Helotes, Bexar County, Texas, and a part by Prof. B. F. Mudge near Dennison, Tex.

The fossils collected by Mr. Walker were sent by him some years ago to the Smithsonian Institution, and have been referred by the Secretary, Prof. Baird, to the office of this Survey for investigation. Those collected by Mr. Marnoch were in part received at the office of the Survey directly from himself, and in part through Prof. E. D. Cope, to whom Mr. Marnoch had previously sent them; and those collected by Professor Mudge were forwarded by himself to the Survey office for investigation.

It is a part of the plan of publication, adopted by the director of the survey, to prepare illustrations of all fossils obtained from strata of the national domain, west of the Mississippi River, whether they have before been described or not. Therefore, the illustrations which accompany this contribution are not only of species here described for the first time, but a large proportion of them represent species that have before been described, but not illustrated, either in the various publications of the Geological Survey of the Territories or elsewhere. Besides these, the various collections sent from Texas are found to contain several species that were described by the late Dr. B. F. Shumard in the Transactions of the Saint Louis Academy of Sciences, but of which no illustrations were ever published. Drawings of a part of them were made by Mr. A. R. Roessler for Dr. Shumard, photographic copies of which were sent to the office of the survey. A part of these have been retouched by Mr. Holmes, by aid of identified specimens of the species from the Texas collections, and appear upon one or two of the plates of illustrations.

The greater part of the drawings of these illustrations have been made by Mr. W. H. Holmes, with his usual great accuracy and care. Those upon Plate X were drawn by Mr. F. D. Owen, and those upon Plate IX

*The plan adopted for the publication of Invertebrate Paleontology of this Survey is as follows: 1. "Paleontological Papers," numbered serially, consisting of preliminary discussions of paleontological subjects, and descriptions of fossils. 2. "Contributions to Invertebrate Paleontology," also numbered serially, and consisting of illustrated memoirs, with more detailed descriptions and discussions. 3. "Monographs," consisting of elaborate treatises of special subjects.

were drawn by the late Mr. Meek, a short time before his death, and represent some of his own species, descriptions of which he had from time to time given in the publications of the Survey, and which were not included in his great work on the fossils of the Upper Missouri River country.

Besides the species thus described by him, and here represented by his own drawings, a number of the other illustrations are of his species, drawn from his original types. It is expected that a careful investigation and identification of the remainder of his types will soon be made, and drawings prepared of them for publication in subsequent reports of the survey.

All the fossils here described and figured are of Cretaceous age, but for want of correct information no attempt has here been made to refer them respectively to the different horizons that geologists have recognized in that great formation in Texas, or to compare those horizons with the recognized divisions of Cretaceous strata in the Northern Territories.

The material, therefore, upon which this contribution is based is presented in a more than usually heterogeneous manner, which prevents, to a great extent, such philosophical discussion as articles of this kind ought to contain. But it is thought best to publish it in its present form, with such explanations and discussions in connection with the descriptions as the subject will warrant, with the hope of making a more philosophic use of the facts here recorded at another time.

RADIATA.

ACTINARIA.

Genus CARYOPHYLLIA Lamarck.

CARYOPHYLLIA JOHANNIS (sp. nov.).

Plate 6, figs. 6 *a* and 6 *b*.

Corallum reversely conical; sides straight or approximately so; calyx slightly oval in outline, moderately deep; septa from 30 to 40, the best example contained in the collection showing 38 at the border of the calyx; not originating in definite cycles, but increasing in number with the growth of the corallum by implantation, at varying distance from the base, between the larger ones already established; their edges prominent, both within the calyx and upon the outer surface, where they form the usual vertical costæ, each alternating costa being a little more prominent than the others, especially upon the outer surface. Under a lens the whole surface is seen to be covered with small, prominent granules. Broken examples show the sides of the septa to be finely corrugate transversely.

Height about 6 millimeters; longer diameter of the calyx, 5½ millimeters; shorter diameter, 5 millimeters.

This species very closely resembles *C. granulifera* Stoliczska from the Cretaceous rocks of Southern India (Palæontologia Indica, vol. iv, part iv, p. 9, pl. 1, figs. 16 and 17); but the septa in that species are about one-quarter more numerous than in the one here described. Besides this, Dr. Stoliczska's figures do not show, and his description does not mention, the regular alternation in the prominence of the costæ which is so plainly apparent in our examples.

Position and locality.—Strata, probably equivalent with the Fort Pierre and Fox Hills Groups of the Upper Missouri, at Cimarron, N. Mex., where it was discovered by Prof. O. H. St. John, in whose honor the specific name is given. These strata are discussed by him in "Notes on the Geology of Northeastern New Mexico," Bull. U. S. Geol. & Geog. Surv. Terr. vol. ii, No. 4.

CARYOPHYLLIA EGERIA (sp. nov.)

Plate 6, figs. 7 *a* and 7 *b*.

Corallum reversely conical or cupuliform; sides more or less convex; base rounded; calyx subcircular, shallow; the border apparently a little thickened and slightly projecting; septa about 30, each alternating one not reaching the columella, their sides are marked vertically by small, slightly-raised ridges, giving their edges a rugose appearance when broken across transversely; columella composed of loosely aggregated, irregular, coarse threads.

All the examples that were discovered are imbedded in rock, and none of them show the outer surface satisfactorily, but the epitheca seems to have been thin, and the vertical costæ not prominent.

Height about 7 millimeters; diameter of the calyx the same; but these proportions vary, some of the examples being proportionally shorter.

The condition of all the discovered examples of both this species and *C. johannis* is such as to render it difficult to satisfactorily ascertain their true generic character, and it is not certain that one or both of them ought not to be referred to *Trochocyathus* Edwards & Haime. They, however, clearly belong to the family *Caryophyllidæ*, and in view of the exceeding rarity of any of the *actinaria* in the Cretaceous rocks of North America, their discovery is of much interest.

MOLLUSCA.

CONCHIFERA.

Genus OSTREA Linnæus.

OSTREA QUADRIPLICATA Shumard.

Plate 5, fig. 6 *a*, and plate 8, figs. 3 *a* and *b*.

Ostrea quadriplicata SHUMARD, 1860, Trans. Acad. Sci. St. Louis, vol. 1, p. 608.
? *Ostrea crenulo-margo* ROEMER, 1852, Kreidebildung von Texas, p. 76, pl. ix, f. 6 *a* and 6 *b*.

The following is Dr. Shumard's description of this species: "Shell small, usually arcuate, rarely elongate-subovate, longer than wide; anterior and basal margins produced into four angles, which are sometimes quite salient, and margin more or less deeply excavated. Superior valve flat, or a little convex at the umbo; beak obtusely rounded or subtruncate at tip; surface elegantly ornamented with imbricating lines of growth, which are crossed by numerous radiating striæ; margins finely crenulate; interior gently concave; muscular impression subovate, situated near the anal border; ligament facet short, subtrigonal, and finely striated transversely. Inferior valve more or less gibbous, posterior slope falling abruptly to the margin; beak moderately sharp, rounded at lip and directed upward and backward; surface with imbricating

concentric [lines], crossed by rather coarse, radiating, bifurcating striæ, and usually four prominent folds, which commence on the umbo at some distance from the beak and terminate at the angles of the border.

"In nearly all full-grown specimens that I have seen the radiating striæ occupy merely the rostral half of the shell. The dimensions of an average specimen are: Length, 1.30 inches; width, 0.80; thickness, 0.40."

This species is much more arcuate than is usual in the typical section of this genus, in which respect it resembles some forms of *Alectryonia;* but it wants the strongly plicated surface and zigzag margins which characterize that subgenus. It doubtless belongs to the typical section of *Ostrea*, although a somewhat aberrant form. It is probable that this species is identical with *O. crenulo margo* Roemer (Kreidebildung von Texas, p. 76, Taf. ix, fig. 6 *a*, *b*); but as Dr. Roemer seems to have obtained examples of the upper free valve only, we are left in some doubt upon this point. In none of the somewhat numerous examples sent by Professor Mudge to the office of the Survey from Denison, Northern Texas, does the upper valve exhibit any plication of the surface, or possess the prolongations from the free convex margin, which are so characteristic of the under valve of the species. Dr. Shumard's figure of the large upper valve, however, shown on plate 8, fig. 3 *b*, shows incipient prolongations of its margin, but its lines of increment indicate that they were not developed until the shell approached maturity. These upper valves, although presenting the variability common to the family, possess all the essential specific characters that are shown by the upper valve of *O. crenulo-margo*, as figured and described by Dr. Roemer. It should be remarked, however, that the collection contains no example with both valves *in situ;* also, that the free margins of the under valve, except those portions between the middle and the beak, show little or nothing of the fine crenulation that marks the entire margin of the upper valve, which character suggested the specific name to Dr. Roemer.

The association of these two valves in the same layers, with no others that could possibly belong together, and the fact that the four long marginal processes of the under valve were not developed until the shell approached maturity, together with their common characteristics, seem to prove, beyond question, that they belong to one and the same species. Dr. Shumard's examples, illustrated on plate 8, were obtained from the bluffs of Red River, Lamar County, Texas; Dr. Roemer's, from Fredericksburg, Tex., and Professor Mudge's, from Denison, Tex.; the latter furnishing those which are illustrated on plate 5.

OSTREA (ALECTRYONIA) BELLAPLICATA Shumard.

Plate 4, figs. 3 *a*, *b*; and plate 8, figs. 2 *a* and *b*.

Ostrea bellaplicata SHUM., 1860, Trans. St. Louis Acad. Sci. vol. 1, p. 608.

This species is more robust than is usual in the subgenus *Alectryonia*, but the strongly plicated surface, zigzag character of the free margins, moderately extended hinge-line, and subalation of the postero-dorsal portion are characters which agree with those of that subgenus, and separate it from the typical forms of *Ostrea*. The following is the original description of the species by Dr. Shumard (*loc. cit.*):

"Shell of medium size, ovate or subcircular, anal and pallial borders rounded; buccal border subtruncate; valves unequal. Superior valve usually flat, but sometimes concave, or even gently convex; hinge margin oblique, nearly straight; beak obtusely angular, angle from 105° to

115°. Inferior valve convex, most prominent along the middle, and sometimes obtusely subangulated; beak acute, prolonged, situated near the buccal side, and slightly curved towards the opposite side; muscular impressions large, moderately excavated, elongate-ovate, upper edge concave. Surface of valves marked with prominent, concentric, waved, imbricating laminæ of growth and form, and from ten to fourteen elevated, obtusely angulated costæ, which originate near the beaks and radiate to the margins.

"In many of the specimens before me all the ribs are simple, but in others some of them are bifurcated. In a few individuals they are sharply angulated at their extremities. The concentric laminæ are generally more distinct and more strongly marked on the superior than on the inferior valve.

"The dimensions of an average specimen are: Length, $1\frac{9}{10}$ inches; width, from beak to base, $2\frac{3}{10}$ inches; thickness, $\frac{8}{10}$ inch.

"This handsome oyster occurs in the greatest abundance in fine-grained sandstone and blue indurated marl, towards the top of the Lower Cretaceous, near Sherman, in the bluffs of Post Oak Creek, and various other localities in Grayson County. It is found in connection with the remains of *Squalidæ*, *Ostrea congesta*, and *Corbula graysonensis*."

The figures of this species on plate 8 are from photograph copies of Dr. Shumard's drawings. Those on plate 4 are drawn by Mr. Holmes from an example collected by Professor Mudge at Denison, Tex.

OSTREA (ALECTRYONIA) SANNIONIS White.

Plate 2, figs. 2 *a*, *b*, *c*, *d*, and *e*.

Ostrea sannionis WHITE, 1876, Powell's Rep. Geol. Uinta Mts., p. 112.

Shell rather small, alate at both sides of the beak, irregularly subquadrate in marginal outline, its longitudinal axis curved, the convexity of the curved side being forward; nearly or quite as wide across the alations as at the base, but much constricted in the middle, especially upon the posterior side; beaks small, not prominent, directed a little backward. Lower valve moderately convex; scar of attachment at the beak small or absent; ligament-area short, rather broad, its longitudinal furrow shallow, but well defined, transversely striated and pointing obliquely backward; posterior alation narrower and more clearly defined than the anterior one and a little longer than the corresponding alation of the opposite valve; muscular scar comparatively large, situated nearly midlength of the valve and near the posterior margin, curved-spatulate in outline, its broader end being toward the base of the shell and the convexity of the curve toward the postero-basal portion. Upper valve nearly flat, but its lateral and basal portions are made very irregular by the coarse and deep plications which are common to both valves.

Surface of both valves marked by the ordinary lines and laminations of growth common to the genus, and also by somewhat numerous crenulated radiating plications in the rostral region, the greater part of which terminate before reaching the borders, but four or five of them, increasing greatly in size as they proceed, reach the basal border of the shell, to which they give a strong zigzag character.

Length from base to beak of one of the larger examples, 39 millimeters; breadth near the front of the same, also 39 millimeters; across the alations, 33 millimeters.

The species of the subgenus *Alectryonia* Fischer are, as a rule, less subject to extreme variation than those of typical *Ostrea;* and this is a

very clearly defined species, the numerous examples of it in the collections showing it to have been subject to little essential variation. It belongs to the typical section of the subgenus, and not to the section of long falciform species represented by *A. carinata* Lamarck and *A. macroptera* d'Orbigny.

Position and locality.—Fox Hills Group; valley of Weber River, near Coalville, Utah.

Genus EXOGYRA Say.

EXOGYRA VALKERI (sp. nov.).

Plate 1, figs. 1 *a* and *b*.

Shell large, broadly subelliptical or oblong in marginal outline, depressed; test moderately thick; larger valve depressed, irregularly convex; dorsal portion flattened and almost at right angles with the plane of the shell, especially near the umbo, from which portion to the general surface it is abruptly rounded; umbo incurved, making more than one complete volution, much depressed beneath the general exterior surface of the valve; muscular impression large, subovate in outline, subcentral; ligamental groove comparatively small, moderately deep, close to the outer margin; pallial margin having a comparatively broad space along its whole length marked by faint radiating crenulations. Smaller valve nearly flat, or slightly and more or less irregularly concave; its umbo flattened and equally incurved with that of the other valve.

Surface of the larger valve marked by the ordinary lines of growth, and, especially upon the incurved side, by irregular knotted ridges upon the concentric lines. Surface of the smaller valve marked by very numerous and distinct, coarse, concentric laminæ of growth.

Length, 14 centimeters; width, $10\frac{1}{2}$ centimeters; thickness, 5 centimeters.

This species belongs to the section of the genus *Exogyra*, which is represented by such species as *E. plicata* Chemnitz (sp.), *E. boussingaultii* d'Orbigny (sp.), and *E. texana* Roemer; the last-named species being also from the Cretaceous rocks of Texas. It differs, however, from all three of these species in being destitute of all radiating plications or folds except those of concentric increment, as well as in other less conspicuous but still obvious characteristics.

Position and locality.—Cretaceous strata; Salado, Bell County, Texas, where it was collected by Mr. D. H. Walker, and in whose honor the specific name is given.

Genus PLACUNOPSIS Morris & Lycett.

PLACUNOPSIS HILLIARDENSIS (sp. nov.).

Plate 7, fig. 14 *a*.

Shell small, broadly oval or subcircular, slightly oblique; test thin, fragile, papyraceous; margins somewhat irregular; upper valve moderately convex; umbo submarginal, the apex depressed and not clearly defined. Surface conspicuously marked with numerous coarse, radiating, irregularly undulating, abruptly raised lines, which are wider than the spaces between them, and some of which appear to have ended at the border, or upon imbricating concentric lines, as tubular or semicylindrical processes. Diameter of the few examples obtained, about 12 millimeters.

Although the hinge and interior of this shell are not known, it seems to be a species of true *Placunopsis* Morris & Lycett, and to be nearly related to their typical species, although the latter (*P. jurensis* M. & L., Monog. Gr. Ool. Mol. p. 6, pl. 6, figs. 8, 8 *a*, and 8 *b*) is of Jurassic age, while the former is Cretaceous. This appears to be the only known species of this genus in the Cretaceous rocks of the United States, but Mr. Meek (U. S. Geol. Surv. Terr. vol. ix, 4to, p. 23) suggests that the *Anomia subtrigonalis* of Meek and Hayden from the Fort Pierre Group of the Upper Missouri probably belongs to the genus *Placunopsis*. Our species differs conspicuously from that one in being radiately marked, and also in the character of its marginal outline and general aspect.

It is true that neither the under valve nor the interior of our species is known, but the characters, so far as they are known, very plainly indicate the genus to which it is referred. In its marginal outline and surface-markings it resembles the *Capulus occidentalis* of Hall and Meek, from the Upper Missouri River Region, as figured by those authors, but the distinct laminated, pearly texture of the shell substance would forbid its reference to that genus if its other characters were less doubtful.

Position and locality.—Strata of the Fox Hills Group; near Hilliard Station, Union Pacific Railroad, Wyoming.

Genus PLICATULA Lamarck.

PLICATULA HYDROTHECA White.

Plate 6, fig. 3 *a* and *b*.

Plicatula hydrotheca WHITE, 1876, Powell's Rep. Geol. Uinta Mts. p. 113.

Shell of ordinary size, a little obliquely and irregularly subovate in marginal outline; rostral region narrowed, its sides nearly straight or only slightly convex; the remainder of the free border somewhat regularly convex or rounded; lower valve broadly convex; hinge-teeth well developed; ligamental fosset moderately large; upper valve nearly flat or slightly concave in the rostral region. Surface of both valves marked by small, slightly raised, radiating plications, which are crenulated, a little irregular, increase in number both by bifurcation and implantation, and are more or less distinct upon all parts of the surface of both valves.

Length, 3 centimeters; greatest breadth, 24 millimeters.

Position and locality.—Cretaceous strata, probably equivalent with the lower portion of the Colorado Group; head of Waterpocket Cañon, Southern Utah.

Collected by Mr. G. K. Gilbert.

Genus PTERIA Scopoli.

PTERIA PARKENSIS White.

Plate 3, fig. 3 *a*.

Avicula parkensis WHITE, 1876, Powell's Rep. Geol. Uinta Mts. p. 115.

Shell rather small, slightly inequivalve, very oblique, elongate, thin at all the margins except the cardinal; anterior wing of ordinary size and shape; posterior wing rather large and long; both valves broadly and somewhat regularly convex; greatest breadth of the shell behind the middle; antero-basal border broadly convex; posterior extremity regu-

larly rounded; postero-dorsal border nearly straight from the posterior border to the base of the posterior wing; beaks having the ordinary prominence; surface smooth or having the usual concentric lines of growth.

Length, from the end of the anterior wing to the posterior extremity of the shell, 34 millimeters; breadth across the widest part of the body, 15 millimeters.

This species resembles the *Avicula lingulifera* of Shumard, but it differs from that species in its more elongate form and more oblique hinge-line.

Position and locality.—Cretaceous strata, probably equivalent with those of the Fox Hills Group; south of Grand River, Middle Park, Colorado, where it was collected by Prof. J. W. Powell.

Subgenus **Oxytoma** Meek.

PTERIA (OXYTOMA ?) GASTRODES.

Plate x, fig. 1 *a*.

Avicula (*Oxytoma?*) *gastrodes* MEEK, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 491.

"Shell (as determined from a left valve) attaining a moderately large size, subtrigonal in outline, rather distinctly convex, and having a very slight backward obliquity; basal outline very profoundly rounded, the deepest or most prominent part being in advance of the middle; posterior margin moderately sinuous below the wing, from the extremity of which it ranges obliquely forward and downward, rounding regularly into the base below; anterior margin strongly and subangularly sinuous under the wing, thence descending with a slight forward obliquity and rounding rather abruptly into the base; hinge-margin longer than the height of the valve, the antero-posterior diameter of which (at any point below) it also decidedly exceeds, ranging nearly at right-angles to the vertical axis of the shell; beak distinctly convex, rising above the hinge-margin, strongly incurved, without obliquity, and situated less than one-third the length of the hinge-margin from the extremity of the anterior wing, which is subtrigonal in form, somewhat convex, a little rounded at the extremity, and very strongly separated from the abrupt shell [swell?] of the umbo by a deep rounded concavity extending from the beak obliquely to the marginal sinus below; posterior wing longer and more compressed, narrower and more angular than the other; both wings, particularly the posterior one, projecting decidedly beyond the margin of the valve below. Surface only showing more or less distinct lines of growth, which are stronger on the wings than elsewhere. Right valve unknown.

"Height of left valve, 1.50 inches; length of same below the wings, about 1.30 inches; length of hinge-line, 1.90 inches; convexity (of left valve alone), 0.40 inch.

"*Locality and position.*—Cretaceous sandstones, Coalville, Utah."

Only a single example of this species has yet been discovered, although I have carefully searched the locality since Mr. Meek originally discovered it. It is in the condition of a sandstone cast, but its external characters are quite clearly shown. It is well represented by fig. 1 *a*, plate x, except that the great convexity of the body of the valve does not fully appear. Mr. Meek adds the following remarks to his original description of this species:

"I have not yet seen the hinge of this shell, or its left* [right] valve, and therefore have some doubts in regard to which of the sections of the old genus *Avicula* it would most properly fall into. If the right valve is (as I am inclined to think the case) nearly flat, with a deep, sharply cut byssal sinus, and its beak not distinct from the hinge-margin, it will probably fall into a little group for which I some time back proposed the name *Oxytoma*, typified by *Avicula Munsteri* Bronn. It differs remarkably from typical species of *Avicula* in its erect form, its umbonal axis being inclined a little backward instead of strongly forward. From *Pseudomonotis*, with which it agrees in its erect form, and the elevated, strongly incurved beak of its right [left] valve, it differs very strongly in having decided, well-developed ears, both in front and behind. Dr. Stoliczska thinks the characters of the genus *Pseudomonotis* should be extended so as to include *Oxytoma*. Should this view prevail, the name of our species would probably become *Pseudomonotis* (*Oxytoma*) *gastrodes*. It seems to me, however, that *Oxytoma* stands more nearly related to *Avicula* proper than to *Pseudomonotis*, as typified by the Permian species *P. speluncaria*, so that if we unite *Oxytoma* to *Pseudomonotis*, I cannot see why we might not, on the same principle, take another step of the kind and restore both to *Avicula*, which I am certainly not inclined to do, though I regard *Oxytoma* as a subgenus under *Avicula*.

"I use the name *Avicula* here, as elsewhere, subject to the change that it is probable the rules of nomenclature will demand in the restoration of the older name *Pteria*, which would require the name of our species to be written *Pteria gastrodes*, if it falls into that group."

Subgenus **Pseudoptera** Meek.

PTERIA (PSEUDOPTERA) PROPLEURA Meek.

Plate x, figs. 2 *a* and *b*, and *c*.

Avicula (*Pseudoptera*) *propleura* MEEK, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 489.
Avicula (*Pseudoptera*) *rhytophora* MEEK, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 490.

After careful examination, not only of all Mr. Meek's type-specimens, which were all found associated in the same stratum, but also others which I have collected at the original locality at Coalville, Utah, I am satisfied that both this species and the form which he described in the same publication under the name of *Avicula* (*Pseudoptera*) *rhytophora* are specifically identical. I therefore refer both forms to *Pteria* (*Pseudoptera*) *propleura*, which name comes first in order in the volume above cited; but I herewith give his description of both forms, together with his remarks upon the same, and also figures of Mr. Meek's types of both forms on plate x:

"Shell, as determined from a left valve, obliquely ovate-subtrigonal, moderately convex along the oblique umbonal slope in front of the middle, and compressed-cuneate behind; posterior margin with its general outline nearly vertical and slightly straightened along the middle, thence extending obliquely upward and a little forward, with a very faint sinuosity above, to the hinge, which it meets at an obtuse angle, while it rounds rather abruptly into the more or less rounded base below; anterior margin ranging obliquely backward and downward nearly parallel

---

*Doubtless an inadvertent error. His example is a left valve, which he describes as such.

to the umbonal slope, faintly retreating near the middle, and from this upward to its connection with the anterior end of the hinge, projecting slightly in the form of a small, short, flattened auricle that is less than rectangular at its extremity above and undefined by any marginal sinus below; hinge-line of moderate length, but not extending quite as far back as the margin of the valve below it; posterior dorsal region flattened, though not forming a proper alation; beak rather pointed, scarcely rising above the hinge, rather oblique, and placed very near the anterior end of the hinge, but not quite terminal. Surface ornamented by moderately distinct lines of growth, which, on the anterior part of the valve, are crossed by seven or more slender, raised, radiating lines, and one stronger rib that extends along the umbonal slope, so as to give it a slightly angular appearance, while very faint traces of fine radiating striæ are sometimes seen on other parts of the valve. Right valve and hinge and interior of both valves unknown.

"Height, measuring at right angles to the hinge, 0.90 inch; length of hinge, about 0.75; greatest antero-posterior diameter parallel to the hinge, about 0.85 inch; length, measuring from the beak obliquely to the most prominent part of the postero-basal margin, 1.20 inches; convexity, about 0.23 inch.

"This species appears to belong to a group of American and European Cretaceous Aviculoid shells that seem to me to be sufficiently distinct from the typical forms of *Avicula* (*Pteria*) and *Meleagrina* to stand together, at least as a separate subgenus. They differ from the typical forms of *Avicula* in having no extended alations or defined byssal sinus in either valve, as well as in presenting a peculiar, more or less obliquely rhombic or subtrapezoid outline. The hinge and interior of these shells are unknown to me, but the former seems not to be provided with a gaping cardinal area, the cardinal edges being thinner and compressed. *Avicula anomala* of Sowerby (1836), as illustrated by d'Orbigny in Paléont. Française, Terr. Crét., tome iii, pl. 392, may be regarded as the type of this section, for which I would propose the name *Pseudoptera*. It includes, in addition to *Avicula* (*Pseudoptera*) *anomala* Sowerby, *Avicula* (*Pseudoptera*) *raricosta* Reuss, and *Avicula* (*Pseudoptera*) *fibrosa* Meek & Hayden.

"The two species here described are only referred to this group provisionally, as their right valves are not yet certainly known. There are some reasons, however, mentioned further on for suspecting that this valve may have a deep byssal sinus in one if not both of these species. If this should be found to be the case, they cannot be properly referred to the above-mentioned group, but would fall into a group for which Stoliczska has proposed the name *Electroma*, typified by the recent species *Avicula smaragdina* Reeve, and thus have to take the name *Avicula* (*Electroma*) *propleura* and *A.* (*Electroma*) *rhytophora*. Should Scopoli's name *Pteria*, however, replace *Avicula*, as I believe the rules of nomenclature will require, and the section to which these shells belong properly fall into that genus, either as a subgenus or otherwise, then the name *Pteria* will have to be substituted for *Avicula* in connection with these species.

"*Locality and position.*—Coalville, Utah; from white sandstone, 250 feet above the lower heavy bed of coal mined at that place."

The following is Mr. Meek's description of and remarks upon the form which he designated as *Avicula* (*Pseudoptera*) *rhytophora*:

"Shell, as determined from a left valve, but slightly oblique, rhombic-suboblong, and nearly twice as high as wide in adult examples, but proportionally broader and subtrigonal in young specimens; moderately convex, the greatest convexity being toward the anterior side, along the umbonal slope, which appears to be angular, thence cuneate posteriorly,

and more or less deflected inward anteriorly; hinge-line very nearly equaling the greatest antero-posterior diameter, and ranging at an angle of about 70° to the umbonal axis; posterior margin nearly straight, or a little convex in outline along the middle, where it ranges at an angle of about 100° to the hinge-margin, but curving a little forward above, so as to connect with the latter at a somewhat more obtuse angle, while below it curves gracefully downward into the narrowly rounded or somewhat angular base; anterior margin a little sinuous in outline in the middle, with a general direction nearly parallel to that of the umbonal slope, but compressed nearly rectangular, and projecting a little beyond the beak above, the projecting part not having the character of an ear or distinct lobe, though defined by a shallow depression extending from the beak obliquely downward and backward to the slightly sinuous central region; beak very nearly terminal, moderately oblique, and rather compressed. Surface with more or less distinct lines of growth, and near the hinge-margin well defined, regular, vertical ridges or wrinkles that seem not to be exactly parallel to the lines of growth. Right valve not certainly known.

"Height of right valve, 3.20 inches; antero-posterior diameter along hinge-line, 1.90 inches; height about half-way down parallel to hinge, 2 inches; convexity, 0.70 inch.

"This species will be readily distinguished from the last, not only by its much larger size and less oblique and broader form, but also by the strong vertical wrinkles along its hinge-margin. It likewise seems to be entirely without any traces of the radiating costæ seen on the anterior side of that species, and has its posterior margin much more nearly vertical above, and slightly convex in outline, instead of a little sinuous there. Its umbonal slope in the only left valve seen seems to be decidedly angular, though this may be partially if not entirely due to an accidental fracture and bending of the valve along that line. It looks, however, like a natural angle with some little nodes or projecting points along its crest. In general form it presents much the outline of some of the large Myalinas of the Western Coal-Measures, such as *M. ampla* and *M. subquadrata*, but it differs not only in its angular umbonal slope, less curved beaks, and wrinkled dorsal margin, but in having its anterior margin flattened and a little extended beyond the beak in front, instead of being concave there, thus not leaving the beak quite terminal, as we see in *Myalina*.

"I am not quite sure that I have seen the right valve of this shell, though one of the same general outline and of corresponding size that was observed in a large mass of rock at that locality was believed to belong to this species.* It was nearly flat and smooth, excepting fine lines of growth, and, if I mistake not, had a tolerably deep, well-defined byssal notch. If it really belonged to this shell, the species can hardly go properly, as already stated, into the group *Pseudoptera*, the type of which has no traces of a byssal sinus in either valve."

As before stated, I regard both these forms as belonging to one and the same species. Figures 2 *a* and *b* on plate x are drawn from Mr. Meek's types of his *Avicula* (*Pseudoptura*) *propleura*, and fig. 3 *a* from a gutta-percha cast of his type (which is a natural mold in sandstone), and only example of his *Avicula* (*Pseudoptera*) *rhytophora*. The latter is doubtless an old shell, while the others are not quite adult. The vertical wrinkles seen near its hinge-margin are faintly indicated upon some of the other

"* The specimen was broken into fragments in trying to detach it from the mass of rock."

examples. The true marginal outline of that large example is also in part obscure in the specimen, and probably does not differ so much from that of the others as Mr. Meek supposed. The angularity of the umbonal ridge of this large specimen is evidently natural and not accidental, as appears more plainly upon the gutta-percha cast which I have made, than upon the specimen; and the umbonal ridge of all the other examples is marked in a similar manner, which really consists of a radiating rib in the case of all of them. It is true that no radiating ribs are to be seen upon the large example in front of the umbonal one, but they are distinct only upon the small examples, which are evidently young, and obscure upon the larger intermediate sizes. They seem to have become obsolete, and finally obliterated with age.

Genus INOCERAMUS Sowerby.

INOCERAMUS HOWELLI White.

Plate 4, figs. 1 *a*, *b*, and *c*.

Inoceramus howelli WHITE, 1876, Powell's Rep. Geol. Uinta Mts. p. 114.

Shell of medium size, obliquely and irregularly suboval in marginal outline, the vertical diameter being greater than the transverse; the left valve greater than the other, but both of them have considerable convexity; beaks narrowed, prominent, the prominence of the left one greater than that of the other; both of them elevated above the hinge-line, and also curving forward beyond the front of the shell; front more or less flattened, extending almost straight downward from the front end of the hinge, with which it forms nearly a right, or slightly obtuse angle; antero-basal margin abruptly rounded to the base; basal margin short; postero-basal margin extending obliquely upward to the posterior extremity, straightened or slightly emarginate; posterior extremity abruptly rounded to meet the almost straight postero-dorsal margin.

Between the axis of the body of the shell and the postero-dorsal margin there is upon each valve a rather broad, shallow, but more or less distinct furrow or depression, extending from the umbonal region to the postero-basal margin and ending in the emargination before mentioned. There is also a distinct alation upon each valve, separated from the body portion by a tolerably well-defined auricular furrow.

Surface marked by the ordinary lines of growth and also by the moderately distinct concentric folds, but the surface has a rather smoother aspect than is common with species of this genus.

Height of an average-sized example, from base to beaks, 7½ centimeters; greatest breadth, which is near the base, 5 centimeters; length of hinge, 37 millimeters.

This shell has the general aspect of *I. fragilis* Hall & Meek, but differs from it in possessing the shallow radiating furrow upon the body of each valve, and also in having a distinct posterior ear, separated from the body of the valve by an auricular furrow. It also resembles an example of *I. striatus* Mantell, in the cabinet of the Smithsonian Institution, from Saxony, but the beaks of our species are more elevated and turned more forward than they are in that species. *I. striatus* is also without the shallow radiating furrow before mentioned. It differs from *I. flaccidus* White (Expl. and Surv. West of 100th Merid. vol. iv, pt. 1, p. 178, pl. xvi, figs. 1 *a* and *b*) in its smaller size, its smoother surface, and more gibbous valves, that species being considerably flattened, and coarsely and extravagantly wrinkled.

Position and locality.—The original examples were collected by Mr. E. E. Howell from Cretaceous strata in Lower Potato Valley, Southern Utah. I afterward discovered some imperfect examples in strata of the Fox Hills Group, near Captain Dodds's ranch, in the valley of Ashley's Fork, Utah.

INOCERAMUS GILBERTI White.

Plate 3, figs. 1 *a, b,* and *c.*

Inoceramus gilberti WHITE, 1876, Powell's Rep. Geol. Uinta Mts. p. 113.

Shell irregularly suboval in marginal outline, the transverse diameter being greater than the vertical; front more or less flattened; valves nearly or quite equal, the left one, if either, the larger, both of them gibbous, and sometimes quite ventricose; umbones broad and elevated; beaks very near the front, incurved, but not projecting beyond the front margin; front nearly straight vertically, or sometimes more rounded, in the former case forming nearly a right angle with the hinge; front margin rounded below to the basal margin, which is broadly convex for more than half the length of the shell; postero-basal margin extending obliquely upward, with a slight emargination, to the posterior extremity, which is abruptly rounded to meet the downward-sloping postero-dorsal margin; dorsal margin straight, its length equaling more than half the long diameter of the shell. Upon each valve there is an obscure radiating depression, or ill-defined furrow, extending from the umbonal region to the postero-basal border, and ending there at the emargination before mentioned.

Surface marked by the usual lines of growth, and also by numerous extravagant, irregular concentric folds or wrinkles.

This species belongs to a section of the comprehensive genus *Inoceramus* that Brongniart designated under the name *Catillus.* It is a peculiarly well-marked species, and readily distinguishable from any other published species from American strata.

Transverse length of an average-sized specimen, 7½ centimeters; height from base to hinge, 5 centimeters.

Position and locality.—Cretaceous strata, probably of the Fox Hills Group; near Last Chance Creek, Southern Utah, where it was collected by Mr. G. K. Gilbert.

INOCERAMUS OBLONGUS Meek.

Plate 2; figs. 1 *a* and *b.*

Inoceramus oblongus MEEK, 1871, An. Rep. U. S. Geol. Surv. Terr. for 1870, p. 297.

Shell large, inflated, longitudinally oblong or suboval in marginal outline, widest near the posterior end; valves nearly or quite equal; hinge-line long and straight; posterior margin long, broadly convex, subtruncating the shell obliquely downward and a little backward; front and basal margins forming a continuous but unequal curve, being greatest in front and least near the postero-basal region; beaks equal, not very large, nearly terminal, raised above the hinge-line, incurved, and pointing very little forward. Test comparatively thin for so capacious a shell.

Surface marked by the ordinary lines of growth, and usually by more or less distinct concentric undulations.

This shell bears some resemblance to *I. barabini* Morton, but it is a much larger and more gibbous shell, the adult examples becoming ex-

tremely inflated with age (when the back of the shell becomes broad and concave), sometimes reaching a length of 19 or 20 centimeters, a height of 10 or 11 centimeters, and a thickness about equal to the height. The usual dimensions, however, are about one-quarter less.

This species was designated by Mr. Meek in a foot-note to a list of the fossils collected by the surveying parties during the year 1870, on page 297 of Ann. Rep. U. S. Geol. Surv. Terr. for 1870. Just previous to his death he had also prepared the drawings of the type-specimens represented by figures 1 *a* and *b*, plate 2, which are there reduced to three-quarters the original size.

Position and locality.—In the list of fossils referred to, the locality is given as "Cache la Poudre River, near Greeley, Denver and Pacific Railroad, Cret. No. 3." During a personal examination of that region in 1877, I found what I presume is the original locality to be about 15 miles west of Greeley and about 6 miles south of Fort Collins. The strata of that portion of the Cretacious series, however, are no doubt exposed at various localities between the Cache la Poudre and the Big Thompson. At the first-named locality numerous specimens of this species were found with both valves in place, weathered out of the harder sandstone concretion distributed in the softer strata, where they are associated with several other species characteristic of the divisions 4 and 5 of the Upper Missouri section.

Genus BARBATIA Gray.

BARBATIA COALVILLENSIS White.

Plate 6, figs. 2 *a* and *b*.

Arca? coalvillensis WHITE, 1876, Powell's Rep. Geol. Uinta Mts. p. 115.

Shell not large, moderately gibbous, transverse length from two-fifths greater to nearly twice as great as the height; beaks depressed, situated near the anterior end; umbones broad, not prominent; anterior end rounded or subtruncate; base usually nearly straight, but sometimes slightly convex, and sometimes a little emarginate about the midlength; postero-basal border rounded upward to the posterior extremity, which is abruptly rounded up to the downward-sloping, nearly straight postero-dorsal border, the latter forming a rounded obtuse angle with the cardinal border; hinge equal in length to about two-thirds the entire length of the shell, consisting of a moderately slender hinge-plate bearing numerous transverse teeth with about equal spaces between them. The posterior teeth have an oblique direction downward and a little forward, which obliquity diminishes toward the front, so that the teeth from about midlength of the hinge to the center of the beak are directly transverse. These central transverse teeth are a little narrower than those farther back, but the two or three teeth in front of the center of the beak are larger than any of the others, and a little curved.

Area apparently nearly obsolete, or at least it is very narrow. Internal markings unknown. A slight depression or flattened space upon the outer surface extends from the umbo of each valve to its base, meeting there the straight or slightly emarginated portion of the basal margin before mentioned.

Surface marked by the ordinary lines of growth, and also by five radiating lines, which are often obscure.

Length of an example a little above the ordinary size, 5 centimeters; height, 33 millimeters.

In the original publication of this species (*loc. cit.*), I was a little mis-

led by the imperfection of the specimens then obtained as to the true character of the hinge. Further collections made at the typical locality by myself have enabled me to correct the description as above and as shown in fig. 2 *b*, plate 6, which is in part a restoration. No entirely perfect example of the hinge has yet been discovered, the posterior terminal portion of series shown in the figure having been reproduced from another example, and the exact condition of the middle portion of the series is not positively known, the doubt in this respect being expressed by the imperfection in the drawing at that point.

Position and locality.—From strata apparently equivalent with those of near the top of the Colorado Group, or the base of the Fox Hills Group; Coalville, Utah. At this locality, the division between those two groups is not easily determined.

Genus CRASSATELLA Lamarck.

CRASSATELLA CIMARRONENSIS (sp. nov).

Plate 5, figs. 3 *a*, *b*, and *c*.

Shell suboval or subtetrahedral in outline by lateral views, moderately gibbous; umbonal ridge usually well defined; valves regularly convex in front of it and flattened and a little compressed behind it; dorsum moderately long and nearly straight as seen by side view; front obliquely truncated to about midheight of the shell, from which point it is regularly rounded to the base; basal border broadly and regularly convex; posterior border obliquely truncated from the dorsum to the postero-basal border, which is abruptly rounded to the base; lunule narrow, well defined, moderately deep, short-lanceolate or narrow-oval in outline; escutcheon comparatively long, lanceolate in outline, well defined by seemingly raised lateral boundaries; beaks small, situated well toward the front, approximate, scarcely incurved, directed, but not deflected toward the front; hinge-plate strong; cardinal teeth well developed, except the posterior tooth of the right valve, which seems to be rudimentary; ligamental fosset large; muscular and pallial impressions well marked and characteristic; free border of the valves distinctly crenulated. Surface marked by fine irregular concentric striæ of growth and also by more or less distinct concentric ridges and furrows. These characters are not well shown in the illustrations of this species on plate 5, because the specimen selected for figuring was covered by an incrusting film of lime-carbonate, as were most of the examples collected. Wherever this incrustation is removed, however, the concentric furrows and ridges are usually quite distinct.

Length, 32 millimeters; height, 25 millimeters; thickness, 18 millimeters.

This species presents a good degree of variation as shown among the specimens in the collection, some being more nearly subcircular and more gibbous than the one figured on plate 5; in which respect they somewhat resemble *C. evansi* Hall & Meek, but the typical examples of the species depart too widely from that species to need comparison. In most of its characteristics it also agrees well with those of the *subgenus Pachythærus* of Conrad, but seems to differ from that form in the rudimentary condition of its posterior cardinal tooth of the right valve before mentioned, and also in the incipient development of a posterior lateral tooth in the right valve and an anterior one in the left valve, both of which extend below the lower border of the hinge-plate.

Associated with the typical forms of this species, which are represented on plate 5, are others, certainly congeneric with, and perhaps only a variety of this species. It is a more gibbous shell, subcircular, or, at least, more rounded in outline, and with scarcely a trace of the umbonal ridge that marks the typical forms. In these respects it closely resembles *C. evansi* Hall & Meek, already mentioned.

Position and locality.—Cretaceous strata, probably of the age of the Fox Hills Group; Cimarron, N. Mex., where they were collected by Prof. St. John.

Genus TANCREDIA Lycett.

TANCREDIA? CŒLIONOTUS (sp. nov.).

Plate 5, figs. 2, *a*, *b*, *c*, and *d*.

Shell irregularly oblong, transverse, moderately convex; margins closed all around; anterior portion narrower and much longer than the posterior; beaks rather large, elevated, especially so above the antero-dorsal margin, approximate, incurved and directed forward; posterior portion very short, obliquely truncated by a broad and regular curve extending from the beaks to the postero-basal margin, which latter is abruptly rounded to the base; basal margin broadly convex; front regularly rounded, joining the antero-dorsal margin by a somewhat more abrupt curve than that by which it joins the base; a large heart-shaped lunule deeply impressed in front of the beaks but less distinctly defined farther forward; a deep inflexion of the hinge-margin, resembling a deep escutcheon, extends from the beaks to about midheight of the posterior end of the shell, so that the hinge-margin is entirely obscured from a side view; posterior muscular impression moderately large, oval, situated near the posterior margin and a little below the midheight of the shell; pallial sinus moderately deep, extending nearly horizontally forward; hinge unknown; ligament apparently external. Surface marked only by the ordinary lines of growth.

Length, 37 millimeters; height from base to umbo, 29 millimeters.

This species is referred with much doubt to the genus *Tancredia*, but it is provisionally so referred on account of its external form, the want of knowledge of its hinge, and the want of positive information as to the true character of the pallial line in that genus. Its moderately thick test, closed margins, strong muscular impressions, and pallial sinus suggest a close relationship to *Donax*, and the horizontal position of the sinus is like that of *Iphigenia* and *Hecuba*, belonging also to the *Donacidæ*.

Its broadly rounded front is unlike what we expect to find in *Tancredia*, and according to some authors its pallial sinus would exclude it from that genus. The characteristic angle of the antero-dorsal margin of *Meekia* is also wanting in this species. It is likely that it will hereafter be found to represent an undescribed group of shells, but this cannot now be formally proposed, because no information as to the character of the hinge has been obtained. However, important differences from known genera have here been indicated as existing in this shell, and if a future discovery of correlated differences in the hinge should be made, I propose for it the name of *Tancredina*.

Position and locality.—Strata of the Fox Hills Group. The example represented by fig. 2 *d*, plate 5, was collected by Mr. J. C. Hersey, 10 miles west of Greeley, Colo. That represented by figs. 2 *a*, *b*, and *c*, of the same plate, is from the collection of Prof. Powell's Survey. Its locality is unknown, but it is probably from Northwestern Colorado.

Genus CYRENA Lamarck.

CYRENA SECURIS Meek.

Plate 3, figs. 2 *a*, *b*, and *c*.

Corbicula (*Cyrena?*) *securis* MEEK, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 494.
Cyrena (*Veloritina*) *erecta* WHITE, 1876, Powell's Rep. Geol. Uinta Mts., p. 117.

Shell of medium size, obliquely subovate in marginal outline when adult, but subcircular when young, gibbous, especially the upper median portion, but somewhat laterally compressed at the postero-basal portion; antero-basal, basal, and postero-basal borders forming a continuous, almost regular, curve; the dorsal outline, by lateral view, also broadly rounded from the beaks to the postero-basal border; front a little concave transversely below the beaks, and also vertically concave from the beaks to a point a little below the midheight of the shell; dorsum longitudinally concave from between the beaks to a point on the posterior margin a little below the midheight of the shell; beaks prominent, approximate, and curved forward; ligament short and narrow. This concavity of the dorsum resembles an escutcheon, except that it is not defined, especially at the ends; it is moderately deep, narrow, and bounded at the sides by the abrupt rounding inward and downward of the surface from the outer side of each valve, so that the hinge-margin is wholly hidden from sight by a side view of the shell; hinge and interior unknown. Surface marked by the ordinary lines and imbrications of growth.

Height, 33 millimeters; antero-posterior width the same; thickness about 22 millimeters.

Mr. Meek's description was made from a single cast in sandstone obtained from strata that are evidently equivalent with those from which the example figured on plate 3 was obtained; the localities being upon opposite sides of an anticlinal axis, and only about three miles apart. This species, as pointed out by Mr. Meek, and shown above, has the external characteristics of the forms which he separated as a subgenus of *Corbicula* under the name of *Veloritina*. Perhaps it belongs to that group, but it is more probably related to *Cyrena dakotaensis* Meek & Hayden, from the Dakota Group of the Upper Missouri Cretaceous series, and *C. inflexa* Meek, from a higher Cretaceous horizon near Gallatin City, since it is, like those species, associated with marine forms; while the species of the group *Veloritina*, so far as they are fully known, are all associated with brackish- and even some fresh-water forms. If this supposition is correct, we have the remarkable fact of certain species belonging to two genera respectively assuming an external form that has been regarded as of subgeneric value. This, perhaps, is not impossible, especially in this case, because the generic difference, as shown by the shells, between *Cyrena* and *Corbicula*, is neither clear nor satisfactory. Among the numerous examples of shells having the external, and in part the internal characters of *Corbicula* which have been found associated with marine forms in Cretaceous strata, I have never detected transverse striation upon their lateral teeth. Because of this and other differences from true *Corbicula*, I refer all these marine Cretaceous forms to *Cyrena*, but they probably also differ from the typical forms of that genus.

Position and locality.—Cretaceous strata of the Fox Hills Group; Hilliard Station, Union Pacific Railroad, Wyoming. In my original description of the species, as *C. erecta* (*loc. cit.*), it was mentioned as occurring at Upper Kanab, Southern Utah, but those examples are now thought to belong to another species, and to a higher horizon.

Cyrena inflexa Meek.

Plate 10, figs. 7 *a* and *b*.

Corbicula (Veloritina) inflexa Meek, 1871, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 493.

The figures of this species on plate 10 were drawn from Mr. Meek's types, and the following is a copy of his original description:

"Shell longitudinally ovate, a little less than two-thirds as high as long, moderately convex; posterior extremity rather narrowly rounded, or apparently sometimes faintly truncated; anterior very short, subtruncated, or more or less sinuous in outline, just in advance of the beaks, on the abrupt forward slope above, and rather abruptly rounded below; basal margin semiovate or semielliptic; dorsal margins inflected and forming a long convex slope from the umbonal region posteriorly; beaks rather depressed, oblique, incurved, and placed near the anterior end; umbonal slopes not prominently rounded; surface merely showing fine, rather obscure marks of growth; anterior muscular impression rather strongly defined and obliquely ovate; posterior muscular impression larger and obscure; pallial line showing a deep, angular, ascending sinus; posterior lateral teeth of hinge very long, linear, and nearly or quite smooth; anterior short; cardinal teeth very oblique.

"Length of a specimen a little under medium size, 1.35 inches; height, 0.39 inch; convexity, 0.68 inch.

"*Locality and position.*—Near Missouri River, below Gallatin City, Mont., where it occurs associated with *Trigonia*, *Inoceramus*, *Cardium Ostrea*, and other marine Cretaceous fossils."

Mr. Meek referred this shell to the genus *Corbicula* and his subgenus *Veloritina*. It is almost certainly not *Corbicula*, as that genus is usually restricted, because its lateral teeth are not transversely striated, and its pallial sinus is very different. As remarked in connection with the description of the preceding species, I refer such shells as that and this one to *Cyrena*, if found associated with marine Cretaceous species and the lateral teeth show no striation. The character of the lateral sinus, however, as pointed out by Mr. Meek, is very like that of the *Veneridæ*, and not like that of either *Corbicula* or *Cyrena*, and it is likely that this shell does not properly belong to either of those genera. But until we can obtain specimens which show clearly the character of all parts of the hinge, I prefer to refer such forms as this to *Cyrena*, as before stated.

Genus CORBULA Bruguiére.

Corbula nematophora Meek.

Plate 3, figs. 4 *a*, *b*, *c*, and *d*.

Corbula nematophora Meek, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 496.
Corbula nematophora White, 1876, Expl. & Surv. West of 100th Merid., vol. iv, p. 188, pl. xvii, fig. 7.

"Shell of about medium size, ovate-subtrigonal, nearly equivalve and moderately convex, with height equaling two-thirds the length; anterior outline rounded; base semi-ovate; posterior extremity somewhat produced and subangular or minutely truncated in outline below; dorsal outline sloping from the beaks, the anterior slope being more abrupt and slightly concave in outline above, and the posterior longer and nearly straight, with a greater obliquity; posterior umbonal slopes more or less angular in each valve, from the beak to the posterior basal extremity; beaks rather prominent, and placed about one-third the length of the

valves from the front. Surface ornamented by small, regular, concentric ridges, or strong lines and furrows, both of which are more distinct on the right valve than on the left, where they are sometimes obsolete.

"Length of largest specimen seen, 0.50 inch; height, 0.32 inch; convexity, 0.25 inch.

"*Locality and position.*—Near Cedar City, Southern Utah, from coal-bearing Cretaceous beds, apparently belonging to the same horizon as the lower part of the coal series at Coalville. It occurs in great numbers, associated with *Turritella coalvillensis* and other forms apparently identical with Coalville species."

This species, as pointed out by Mr. Meek, closely resembles some of the varieties of *C. perundala* Meek & Hayden, but it differs sufficiently from any other form yet found in any marine Cretaceous strata. Some small specimens of apparently the same species were found among the fresh- and brackish-water Cretaceous forms at Carleton's coal mines near Coalville, but the typical examples are associated with marine forms.

Genus CARDIUM Linnæus.

CARDIUM PAUPERCULUM Meek.

Plate 9, fig. 3 *a*.

Cardium pauperculum MEEK, 1872, An. Rep. U. S. Geol. Surv. Terr. for 1870, p. 306.

The following is Mr. Meek's description of this species, and as no additional examples of it have been collected, no further determinations have been made concerning its characters and relations. The illustration, fig. 3 *a*, plate 9, was drawn by Mr. Meek shortly before his death, and represents one of the better-preserved examples in the collection:

"Shell small, very thin, rather compressed, subovate or subcircular; beaks moderately prominent and nearly central; surface ornamented by about thirty regular, simple, distinctly defined, radiating costæ, which about equal the intermediate furrows, and (owing to the thinness of the valves) are well defined internally, and thus impart a plicated or crenated character to the margins; crossing these are numerous very regular, well-defined, delicate marks of growth, that are usually less distinct on the posterior third, but give a neatly crenulated appearance to the costæ further forward.

"The specimens of this little shell are rarely more than about 0.50 inch in diameter, and are all more or less flattened or otherwise distorted. Sometimes they are distorted by antero-posterior pressure, so as to present somewhat the appearance and outline of a *Lima*, being higher than wide, and more or less oblique; while in other examples they are distorted by vertical pressure, so as to present little or no obliquity and to show a greater antero-posterior diameter than height. I have not seen the hinge, but some impressions in the matrix show that it has anterior and posterior lateral teeth like those of *Cardium*. It, however, does not properly belong to the typical section of that genus.

"*Locality and position.*—Fort Benton Group, or No. 2 of the Upper Missouri Cretaceous series, at Oil Springs, 20 miles west of Fort Bridger, Wyo."

CARDIUM TRITE (sp. nov.).

Plate 5, figs. 4 *a* and *b*.

Shell broadly subovate or suborbicular, height and width about equal; valves gibbous, regularly arching from beak to base; median portion

regularly convex; sides a little flattened above the middle; rostral portion narrowed, elevated, arched; beaks situated well toward the front, much elevated above the hinge-line, prominent, incurved, approximate, and turned very slightly, if any, forward; hinge-margin moderately long for a species of this genus; front having a short, oblique truncation above, from the lower end of which the whole free margin of the shell is continuously rounded to the posterior extremity of the hinge, the convexity varying, but not very greatly, in different parts. Surface marked by very numerous fine costæ of nearly uniform size on all parts of the shell, every third one of which only, bears upon its back many small nodes or short spines.

Height, from base to beak, 35 millimeters; width, 36 millimeters. The height is, however, sometimes greater than the width.

This species bears more resemblance to *C. curtum* Meek & Hayden than to any other species of *Cardium* yet described from the Cretaceous rocks of the West, but the prominent umbonal ridge, and the coarser and non-spiniferous costæ of that species, besides many other details, clearly separate it from the species here described; the peculiar character of the surface-markings also separate it from any other described species with which it is in any danger of being confounded.

Position and locality.—Cretaceous strata, probably equivalent with the lower portion of the Colorado Group; head of Waterpocket Cañon, Southern Utah. Collected by Mr. G. K. Gilbert.

Cardium ———?.

Plate 9, figs. 2 *a*, *b*, and *c*.

The illustrations of this species on plate 9 were drawn by Mr. Meek only a short time before his death, and were intended to represent a new species, which, however, I have not yet been able to identify by specimens in the collections of either the Survey or Smithsonian Institution. Therefore no description is attempted, but the illustrations are given for the purpose of presenting to the public the latest labors of that distinguished author, and to aid in the future identification of the species. The illustrations represent a species closely related to the *C. curtum* of Meek and Hayden; but it differs conspicuously from that species in having the costæ that cover the space behind the umbonal ridge smaller (instead of larger as they are in that species) than they are on the greater surface of the shell in front of the ridge. Upon its identification by discovered specimens, I propose for it the name *C. ultimum*, in allusion to the last work done by the late Mr. Meek.

Trapezium truncatum Meek.

Plate x, figs. 6 *a* and *b*.

Pachymya? truncata Meek, 1871, An. Rep. U. S. Geol. Surv. Terr. for 1870, p. 301.
Trapezium truncatum Meek, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 493.

"Shell small, longitudinally oblong, very convex; posterior side long, distinctly and rectangularly truncated, apparently closed; pallial margin nearly straight and slightly sinuous along its entire length; anterior margin truncated a little obliquely forward from the beaks to the rather prominent and abruptly rounded, or subangularly anterior basal extremity; cardinal margin nearly straight and parallel to the base; beaks depressed nearly to the horizon of the dorsal margin, very oblique, somewhat compressed, and placed less than one-fifth the length of the valves

behind the anterior extremity; posterior umbonal slopes quite prominent or subangular, and continued obliquely to the posterior basal angle, so as to divide the surface of each valve into two nearly equal, elongated, inequilateral triangles, the lower of which forms the concave flanks; anterior muscular scar small, but very deep; posterior muscular scar larger, shallow, suboval; pallial line not distinctly seen, but apparently with a small sinus. Surface with rather coarse, irregular marks of growth.

"Length, 1.15 inches; height, 0.55 inch; convexity, 0.58 inch.

"*Locality and position.*—The specimen was given to Dr. Hayden at the Salt Lake, and was found in that region, but he could not ascertain the precise locality. It is almost certainly Cretaceous."

There were three examples of this species found among the collections formerly in Mr. Meek's hands for investigation, of one of which two views are given on plate x. Nothing further has been learned as to their true locality and position. Neither has anything further been learned concerning the hinge or internal characters of the shell, but it is probably correctly referred to *Trapezium.*

TRAPEZIUM ? MICRONEMA Meek.

Plate x, fig. 5 *a*.

Trapezium micronema MEEK, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 493.

"Shell attaining a rather large size, elongate-trapeziform, the length being a little more than twice the height, which is about one-third greater than the convexity; anterior margin very short and round; posterior margin obliquely truncated above and narrowly rounded below; base nearly straight, or faintly sinuous along the middle, rounding up rather abruptly at each end; dorsal margin long, straight, and parallel to the base; beaks depressed nearly or quite to the horizon of the dorsal margin, and located one-sixth the entire length of the valves from the anterior margin; umbonal slopes prominently rounded from the beaks obliquely backward and downward nearly to the posterior basal extremity, while below this convexity a shallow concavity extends from each beak obliquely backward to near the middle of the basal margin. Surface with numerous very fine, regular, crowded, thread-like radiating lines.

"Length, 2.28 inches; height, 1.21 inches; convexity, 0.90 inch.

"I know nothing of the hinge of this shell and merely place it in the genus *Trapezium* from external characters. Its form and surface markings, however, are such as to leave little room for doubts in regard to its relations to that genus or *Coralliophaga.*

"*Locality and position.*—Cretaceous coal-bearing sandstones at Bear River City, on Sulphur Creek, Wyoming."

No other than the type-specimen of this species has yet been discovered, and consequently nothing further is known of its characters.

BARODA WYOMINGENSIS Meek.

Plate x, figs. 3 *a* and *b*.

Tapes wyomingensis MEEK, 1871, An. Rep. U. S. Geol. Surv. Terr. for 1870, p. 310.
Baroda wyomingensis MEEK, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 493.

The following is Mr. Meek's original description of this species, only a single specimen of which has been discovered among the collections examined by him, but that is evidently his type and only example. It is figured on plate x.

"Shell elongate-subelliptic in outline, much compressed; extremities nearly equally rounded; pallial margin straight and nearly parallel to the dorsal, but rounding up regularly at both ends; dorsal side straight or very slightly convex in outline; beaks depressed nearly or quite to the dorsal margin and placed about one-fourth the length of the valves from the anterior end; anterior muscular impression ovate, rather well defined, and with its longer diameter ranging vertically; pedal scar distinct, near the upper end of that of the anterior adductor; posterior muscular impression very shallow; pallial line with its sinus rather deep, horizontal, and obtuse at the end. Surface with lines and some small ridges of growth.

"Length, 1.70 inches; height, 0.82 inch; convexity, about 0.28 inch."

Mr. Meek also makes the following remarks concerning the relations of this shell:

"The only specimens of this species yet obtained are mainly casts retaining some portions of the shell. They give very little idea of the nature of the hinge beyond the fact that it seems to have three diverging cardinal teeth, the exact form and arrangement of which cannot be made out. The general expression of the shell, however, is very nearly that of some European Cretaceous forms that seem to have essentially the hinge characters of *Tapes*, though they may not be exactly congeneric with the recent species of that genus. Among the foreign species our shell seems to be most nearly represented by *Venus fragilis* d'Orbigny (from the Cretaceous of France), which is not a true *Venus*, but has been referred by Mr. Zittel to the genus *Tapes*. (See Bivalven der Gossaug. Nord Alpen. Compared with d'Orbigny's figure and description of his *V. fragilis*, given in the Paléont. Française, our shell differs in being regularly rounded instead of truncated posteriorly. It is also straighter on the basal margin and more broadly rounded in front. In some of these characters it agrees more nearly with Professor Zittel's figures, which I suspect may represent a distinct species from that figured by d'Orbigny. Still it differs from Professor Zittel's figures in having its anterior margin more broadly rounded and its pallial margin straighter in outline.

"*Locality and position.*—Mouth of Deer Creek, on North Platte, in Wyoming Territory; Fox Hills Group of the Upper Missouri Cretaceous series."

Two years after this description was written, Mr. Meek referred this species to the genus *Baroda* Stoliczska (*loc. cit.*) in which he was probably right, although nothing further is known concerning the hinge of the species. It is evidently congeneric with the following species, which I also refer to *Baroda*.

BARODA SUBELLIPTICA (sp. nov.).

Plate x, figs. 4 *a*, *b*, *c*, and *d*.

Shell subelliptical in marginal outline, moderately compressed, that is, the valves have comparatively slight convexity; anterior and posterior extremities both somewhat regularly, nearly equally, rounded, the posterior being a little narrower than the front; basal margin broadly convex and regularly rounded upward, both anteriorly and posteriorly; dorsal border broadly convex and regularly rounded downward, both anteriorly and posteriorly; beak small, moderately prominent, and placed nearly midlength of the shell. The hinge is not fully known, but as that of the left valve is partially shown by the larger of the two examples figured on plate x, it appears to be furnished with three teeth. Two of them are

of moderate size, the position of the posterior one of which is directly beneath the beak, and both are directed somewhat forward. The posterior one of the three is much the longest and diverges very obliquely backward. Muscular impressions and pallial line unknown. Surface comparatively smooth, but marked with concentric lines and faint undulations of growth.

Length of the larger example, 35 millimeters; height from base to beaks, 23 millimeters.

By the characteristics of the hinge of this shell, so far as they can be ascertained, it appears to belong to the genus *Baroda* Stoliczska, but the shell is proportionally shorter than those of this genus usually are, and its beaks are also more medially situated than is usual in *Baroda*. Externally it has much the appearance of those Cretaceous forms which are usually referred to *Tellina*. It resembles in outline the *Tellina* (*Palæomœra*) *inconspicua* of Forbes, as figured by Stoliczska in vol. iii, Palæontologia Indica, plate iv, fig. 8, but the character of the hinge, so far as it has been seen, forbids the reference of this shell to *Tellina*.

Position and locality.—Strata of the upper portion of the Fox Hills Group; at the mouth of the Saint Vrains, Northern Colorado, where it was discovered by Mr. W. H. Holmes.

MACTRA? HOLMESI Meek.

Plate 6, figs. 4 *a*, *b*, and *c*.

Cyrena? holmési MEEK, 1875, Bull. Geol. and Geog. Surv. Terr., vol. 1 (2d ser.), No. 1, p. 45.

"Shell under medium size, thin, transversely ovate or subtrigonal, rather compressed; anterior side shorter than the other and rounded in outline; posterior moderately produced and subtruncated at the extremity; basal margin transversely semiovate, its most prominent part being antero-centrally; beaks somewhat depressed and placed about half-way between the middle and the anterior; dorsal margins forming a rather long, nearly straight, or slightly convex, gentle slope behind the beaks, and declining more abruptly in front, with a distinctly sinuous outline just before the beaks; surface ornamented with numerous fine, regular, sharply defined concentric lines.

"Length, 0.62 inch; height, 0.54 inch; convexity, about 0.32 inch.

"There are among the specimens apparently of this species quite a variety of forms, produced, as I am inclined to believe, mainly at least, by accidental distortion, though they may represent several distinct species. The specimen from which the foregoing description and measurements were derived presents the appearance of not having been distorted, and, as may be seen by the measurements, is decidedly longer than high. Others, however, agreeing exactly in surface-markings and most other characters, have the length and height nearly equal, or the latter even a little greater than the former. Some of the specimens also differ from that taken as the type of the species in having the posterior umbonal slopes prominent and subangular all the way from the beaks to the posterior basal extremity, instead of only moderately convex. As above intimated, however, all of the specimens departing decidedly from the typical form show more or less indications of accidental distortion and present precisely the same surface-markings as the typical specimen.

"In regard to the generic relations of these shells, the specimens are far from satisfactory, none of them showing the muscular or pallial im-

pressions or the cardinal teeth. Some of the casts, however, show that there was a posterior lateral tooth in one or both valves, rather elongated, parallel to the posterior dorsal margin, and a much shorter anterior lateral close to the beak. Of course it will be impossible to determine the generic characters of these shells until more satisfactory specimens can be obtained, and it is only provisionally that the species is now referred to the genus *Cyrena.* The specific name is given in honor of Mr. William H. Holmes, the artist of the Survey, who discovered the type-specimens.

"*Locality and position.*—On Ralston [Van Bibber?] Creek, three or four miles north of Golden City, Colo., from beds supposed to hold a position from 400 to 500 feet above the beds of coal mined at Golden City. Probably of Tertiary age. I think Dr. Peale found the same species farther south, between Golden and Colorado Springs, not far from the latter. No other fossils were found associated with it."

Figs. 5 *a* and *b*, plate x, represent what is understood to be the form referred to in the closing paragraph quoted above as having been collected by Dr. Peale in the neighborhood of Colorado Springs. The specimens are all imbedded in hard rock, but by breaking many of them they are found to have essentially the hinge structure of *Mactra*, but the minor details of parts of the hinge have not been satisfactorily ascertained on account of the brittleness of the fragile shells and the compactness of the imbedding rock.

Figure 4 *c*, on plate 6, is drawn from Mr. Meek's type. Figures 4 *a* and *b* of the same plate are of associated examples. An examination of a number of examples obtained by myself at the typical locality, four miles north of Golden City, leaves little or no doubt in my mind that the true *Cyrena? holmesi* also has a hinge in all respects like that of the other form from near Colorado Springs, which, as before remarked, is essentially like that of *Mactra.*

I have not been able to ascertain with precision the geological age of the stratum from which the last-named forms were obtained, but if the shells belong, as I suppose, to the *Mactridæ*, we must, in this case, necessarily assume them to be of not later date than the Fox Hills Cretaceous Group, because that group embraces the last of the true marine deposits in that part of the continent. Resting immediately upon the Fox Hills Group is the Laramie Group, all the known faunal remains of which are of brackish-water, fresh-water, or land habitat, which of course embrace no *Mactridæ.* Above the Laramie Group all the deposits are of fresh-water origin.

As to the strata from which the typical examples of *Cyrena? holmesi* were obtained, after a careful personal examination of the locality, I have no doubt that they really belong to the Fox Hills Group,* and that they have, at that point, been completely inverted by the great outflow of trap, a large part of which still rests on the neighboring Table Mountain, and the great vent of which is clearly traceable immediately adjacent to the fossil locality.

---

* This view is still further strengthened by the discovery, by Mr. Arthur Lakes, of Golden City, of an unmistakable fragment of a *Scaphites* in the same stratum with the shells here described.

Since the foregoing portion of this note was written, Mr. Lakes has sent to the Survey a box of fossils from Bear Creek, near Morrison, Colo., among which is a mass of calcareous stone from "750 feet below the coal," charged with shells having all the characteristics of *Cyrena? holmesi* Meek, and also containing a fragment of a *Scaphites* (*S. mandanensis* Morton?), which is evidently identical with the fragment that Mr. Lakes found associated with *Cyrena holmesi* Meek at the typical locality. This leaves no doubt of the Cretaceous age of the last-named species.

I am much disposed to agree with the opinion expressed by Mr. Meek, that these two forms are specifically identical. I have no doubt he was influenced in the provisional reference of the shell which he named *Cyrena? holmesi* to that genus, rather than to *Mactra*, by the supposition that the strata from which it was obtained were those of the Lignitic or Laramie Group, which he at that time regarded as Tertiary, because the characters of the shell, so far as he had determined them, were common to both the *Cyrenidæ* and *Mactridæ*. That is, he saw only the lateral teeth of the hinge. He mentioned nothing about an external ligament, such as characterizes *Cyrena*, and I have not been able to detect a trace of any such ligament in any of the specimens examined; and those forms from the neighborhood of Colorado Springs certainly do not possess any.

By a comparison of the figures 4 *a* and *b* with 5 *a* and *b*, on plate 6, it will be seen that the latter, representing the form from north of Golden City, is shorter than the other form from the neighborhood of Colorado Springs, but not proportionally shorter than Mr. Meek's type; but, as Mr. Meek has shown, the specimens have all, or nearly all, been distorted by pressure in the soft shale in which they are imbedded, and in which they are all in the form of casts. On the contrary, those from near Colorado Springs are completely preserved in form and texture, including the most delicate markings of the surface. It is possible that these two forms belong to distinct species, but it is not probable.

There are certain features in these shells, common also to some others that have been discovered in the Cretaceous strata of the West, that suggest at least a subgeneric distinction from the typical forms of *Mactra* different from any of the published subgenera, but they doubtless belong to the family, *Mactridæ* as before stated.

MACTRA? CAÑONENSIS Meek.

Plate 9, figs. 11 *a*, *b*, and *c*.

Mactra? cañonensis MEEK, 1871, An. Rep. U. S. Geol. Surv. Terr. for 1870, p. 308.

The following is Mr. Meek's original description of this species, and the figures of it on plate 9 are from his own drawings:

"Shell small, very thin, transversely subovate, rather compressed or moderately convex, with length about once and a half the height; anterior side rounded; posterior side longer, narrower, and obliquely subtruncated at the extremity; pallial margin forming nearly a semiovate curve, being most prominent anteriorly, straight or very slightly sinuous behind the middle, and rounding up very abruptly to the lower part of the truncated posterior margin; dorsal outline nearly straight and sloping to the truncated posterior, and declining more abruptly in front; beaks small, moderately prominent, and placed one-third the length of the valves from the anterior margin; posterior umbonal slopes rather prominent to the posterior basal extremity, while the sides in front of this prominence are flattened, or even slightly concave below. Surface with rather regular but distinct lines and furrows of growth. Muscular impressions shallow, posterior round-oval, anterior narrower, with a slender prolongation above; pallial line with a shallow, rather rounded sinus.

"Length, 0.78 inch; height, 0.53 inch; convexity, 0.31 inch.

"*Locality and position.*—Cañon City [Colo.]."

It now seems almost certain that this form is specifically identical with *M. holmesi* (=*Cyrena? holmesi* Meek), the principal observable dif-

ference being that of size. But in the absence of full knowledge concerning the hinge of either of these forms I prefer at present to leave it under the designation originally given it by Mr. Meek. Compare the description of this form with that of *M. holmesi*, immediately preceding; and also compare figs. 11 *a*, *b*, and *c*, on plate 9, with figs. 4 *a*, *b*, and *c*, and figs. 5 *a* and *b*, on plate 6.

Genus PACHYMYA Sowerby.

PACHYMYA AUSTINENSIS Shumard.

Plate 8, figs. 1 *a* and *b*, and plate 5, figs. 7 *a* and *b*.

"Shell very large, length more than double the width, and less than double the thickness; greatest width near the center, where the shell is very gibbous; subangulated diagonally from the posterior side of the beak to the anal extremity and sloping to the margins; posterior slope broad; sides constricted anteriorly by a broad, shallow depression, which commences some distance below the beaks and extends obliquely backward and downward to the base; superior and inferior margins subparallel; buccal end very short, narrowly rounded; anal end obliquely truncate, gaping, angulated at extremity; pallial margin concave in the middle, rounded before, flattened, incurved, approximate; surface marked with irregular concentric lines of growth.

"Length, 6.30 inches; width, 2.30; thickness, 3.64.

"This shell is very nearly related to, if not identical with, *P. gigas* of Sowerby (Min. Conch. vol. 6, p. 1, pl. 504, 505). The only essential points of difference that I can perceive are that in the foreign shell the beaks are situated nearer the anterior extremity, and the sides do not exhibit the oblique anterior depression which appears to be a constant feature in the Texan fossil."

Dr. Shumard reports this fossil as from the "Washita limestone on Shoal Creek, near Austin, associated with *Terebratula wacoensis*, *Turrilites brazoensis*, and *Ostrea subovata*." A large specimen sent to the Smithsonian Institution, from Salado, Bell County, Texas, by Mr. D. H. Walker, measures 22 centimeters in length, a dorsal view of which is shown on plate 8, fig. 1 *b*, reduced one-half its natural diameter. A young example, also sent by Mr. Walker, is shown on plate 5, figs. 7 *a* and *b*.

The illustration, fig. 1 *a*, Plate 8, is a reduced copy from a photograph of one of Dr. Shumard's original drawings, about two-thirds natural diameter. The large example first mentioned is a natural cast, and shows a deep, narrow groove passing obliquely downward and a little backward, immediately behind the anterior adductor scar, which disappears before reaching the base of the shell, and which, of course, represents a ridge upon the inner surface of the shell, much like what occurs in *Pleurophorus*. The scar of the anterior adductor is large, and situated very near the front margin.

PACHYMYA ? HERSEYI (sp. nov.).

Plate 5, figs. 5 *a* and *b*.

Shell small, elongate-oblong, wider posteriorly than anteriorly, inflated, greatest thickness a little forward of the middle, slightly gaping behind; beaks depressed, approximate, incurved, placed near the front; basal margin nearly straight, or only slightly convex; posterior margin trun-

cating the shell obliquely downward and backward, meeting the basal margin by an abrupt curve, and the cardinal margin by an obtuse angle; cardinal margin nearly straight, not quite parallel with the base, because the shell is wider behind than in front; front short, truncated downward and forward from the beaks to about midheight of the shell, and then abruptly rounded to the basal margin; posterior umbonal ridge rounded, prominent, and ending at the projecting postero-basal margin; postero-dorsal space, or that above the umbonal ridge, so compressed as to make that portion of the shell thin and sharp, quite in contrast with the obtuse angle formed by the meeting of the two valves at the base. Hinge and interior markings unknown. Surface marked by the ordinary lines and imbrications of growth.

Length, 25 millimeters; height from base to beaks, 8 millimeters; height near the posterior end, 10 millimeters; greatest thickness, 10 millimeters.

This species is perhaps related to *Pachymya truncata* Meek,* but differs from that species in having its posterior margin very obliquely, instead of rectangularly, truncated; its cardinal and basal margins are not parallel as in that species, and its beaks are placed nearer the front, besides other less conspicuous differences.

It is referred to *Pachymya* with some doubt, mainly on account of the thinness of the test and the general delicacy of the shell. It is possible that it should be referred to *Trapezium*, but no trace of the radiating striæ, which usually mark the surface in that genus, have been detected in this species, and it lacks the general facies as well as the form of that genus.

Position and locality.—Cretaceous strata of the Fox Hills Group; near the confluence of the Saint Vrains with the South Platte, Northern Colorado, where it was collected by Mr. J. C. Hersey, in whose honor the specific name is given. Specimens of this species have also been sent to the office of the Survey by Mr. L. C. Woster, from strata of the same horizon 10 miles west of Greeley, Colo. The Survey is indebted to both these gentlemen for the privilege of examining important and interesting collections of fossils.

Genus GLYCIMERIS Lamarck.

GLYCIMERIS BERTHOUDI (sp. nov.).

Plate 6, figs. 1 *a* and *b*.

Shell irregularly oblong in marginal outline, moderately gibbous, widely gaping behind; dorsal margin nearly straight, or rising a little backward from the beaks, making it slightly concave; base straight or slightly emarginate, and subparallel with the dorsal margin; posterior margin long, obliquely truncating posterior end downward and forward, the basal and posterior margins forming almost a true obtuse angle with each other; posterior margin abruptly rounded to the dorsal margin; front regularly rounded, the rounding being a little more abrupt to the dorsal than to the basal margin; beaks placed a little in advance of the middle, comparatively small, elevated above the hinge-line, and incurved,

---

*In a subsequent publication, Mr. Meek (Annual Report U. S. Geol. Sur. for 1872, p. 493) expresses the opinion that this species belongs to the genus *Trapezium*, and not *Pachymya*. I have not so referred the species here described, although it is possibly congeneric with that of Mr. Meek, because, while I have doubts as to its being a true *Pachymya*, I have likewise doubts as to the propriety of referring it to *Trapezium*, at least before its hinge shall be fully known.

but not turned forward; a distinct sulcus radiates from just behind each of the beaks toward the postero-dorsal margin, but becomes obsolete before reaching it. These sulci give the back of the shell a hollowed appearance behind the beaks. Another linear depression, but a faintly defined one, extends from the posterior side of the beak to the obtuse postero-basal angle of the shell, its position being immediately behind that of an umbonal ridge, if one existed.

Surface marked by the usual lines of growth and also by strong concentric wrinkles, which latter are a little stronger in front of than behind the faintly defined umbonal depression before mentioned.

Length, 85 millimeters; height from base to beaks, 53 millimeters; thickness, about 34 millimeters.

The hinge of this species has not been seen, but the external characteristics of the shell are so in keeping with those of the typical forms of *Glycimeris* as to leave no doubt that it is properly referable to that genus. Indeed, it bears considerable resemblance to *Mya glycimeris*, Lamarck's type of the genus; but it differs from that species in the greater proportionate height of the shell behind the beaks, the great length of the posterior border and its downward and forward truncation of the shell, the angular character of the postero-ventral border, &c. Our type-specimen is very like one in the cabinet of the Smithsonian Institution labeled "From near Marlboro, N. J.," and which probably belongs to the *Panopœa decisa* of Conrad; but the hinge-line of our species is straighter, and both the antero and postero-dorsal portions are more elevated and more compressed. The only other American species with which it need be compared is *G. occidentalis* Meek & Hayden, vol. ix (4to series), U. S. Geol. Surv. Terr., p. 250, pl. 39, figs. 9 *a* and *b*; but it differs from that species in the peculiar posterior truncation before mentioned, the greater proportionate length of the hinge-margin, and the greater prominence and elevation of the antero-dorsal, as well as of the postero-dorsal portion. The specific name is given in honor of Capt. E. L. Berthoud, of Golden City, Colo., to whom the Survey is indebted for interesting fossils and many accurate observations, the result of his large experience in the Rocky Mountain region.

Position and locality.—Strata apparently equivalent with Cretaceous No. 3, or Fort Pierre Group of the Upper Missouri section; about 15 miles west of Greeley and about 6 miles south of Fort Collins, Colo.

Genus PARAPHOLAS Conrad.

PARAPHOLAS SPHENOIDEUS White.

Plate 5, figs. 1 *a*, *b*, *c*, and *d*.

Turnus sphenoideus WHITE, 1876, Powell's Rep. Geol. Uinta Mts., p. 117.

Shell elongate, cuneate, inflated in front, narrowed and laterally compressed behind; beaks anterior, incurved, adjacent; dorsal margins of the valves straight and sloping from the beaks to the posterior end, capped or connected by a slender, styliform, plain, accessory plate; posterior extremity small, truncated, or narrowly rounded; basal margins nearly straight, connected by a ventral accessory plate similar to the dorsal one, except that it is shorter, broadest behind, but coming to a slender point in front about midlength of the shell longitudinally, divided by a linear groove; front regularly rounded, both vertically and laterally; anterior gape consisting of a narrow, vertical slit, which occupies the middle of a somewhat prominent projection at the antero-basal

portion of the shell, which projection has the shape of a Norman shield, as seen by front view when both valves are in their natural position, and which seems to have been occupied by a much wider gape in the younger than in the adult condition of the shell; both umbonal grooves distinct, both upon the outer surface and upon that of the stony cast; anterior groove broader and deeper than the other, but both are slender; besides the two umbonal grooves there is another somewhat broader groove or furrow, extending with a broad, downward curve from the posterior side of the beak to the posterior end of the shell. This groove, like the other, is distinctly traceable upon the outer surface, but is more distinctly seen upon the stony cast.

A broad, subcircular, cake-like umbonal accessory valve covers the beaks and the space between them, the valve being divided by a suture into two nearly semicircular pieces, so neatly that it is hardly perceptible until the valves are slightly displaced. The margins of the principal valves between the beaks and the Norman shield-shaped projection are narrowly but abruptly everted, which, with the beaks above and the borders of the projection below, bound a distinctly hollowed space on each side and below each beak. Besides the grooves before mentioned, the surface is marked by fine concentric, distinctly raised lines on each side of the shell, but they are less distinct upon the surface of the Norman shield-shaped projection than elsewhere. Between the posterior groove or furrow before mentioned as ending at the posterior margin of the shell and the dorsal margin, the surface is occupied by strong, irregular scales and laminæ that were successively left as the shell increased in size.

Length, 13 millimeters; greatest height, 7 millimeters; breadth at front, 6 millimeters.

Since publishing the original description of this species (*loc. cit.*), I have had opportunity to examine additional examples, which show its characteristics more completely than they were known before. This is shown in the modified description of the species and the reference of it to *Parapholas* Conrad, instead of to *Turnus* Gabb, as was done before. Although its outward form is quite different from that of the typical species of *Turnus*, I then believed the posterior umbonal groove, which I saw only in the stony cast, to represent an internal rib, and not a groove in the test. Mr. Gabb also mentioned the discovery of fragments of tubes associated with his examples of *Turnus*, which led him to believe pertained to those shells, thus relating them to *Teredo* on the one hand, while other characters connected them to the *Pholodidæ*. I had also detected fragments of tubes associated in the same mass of rock with this species, but later examination leads me to believe that they belong to a true *Teredo*, although the valvular portions have not been discovered. These tube-like specimens, together with the shells here described, were contained in small, irregular, nodular, impure lime-carbonate masses, of three or four inches in diameter, the somewhat distorted tubes traversing them irregularly; but most of the specimens here described were found with their anterior ends all pointing toward the center of the nodules, with their posterior ends pointing outwards, and placed near the outer surface of the nodule. The nodules were found to contain a few fragments of unmistakable fossil wood. It is probable that this wood was bored by both the *Teredo* and the *Parapholas*, and as that decayed, the shells formed a nucleus around which the lime-carbonate formed the nodular masses in the shale in which they were discovered.

I am not fully satisfied now that this species really belongs to *Parapholas* Conrad, or to any other published genus; but I refer it to *Parapholas* mainly because Stoliczska has adopted that name for some Cretaceous

shells of Southern India which are evidently congeneric with this species. Apparently entertaining similar doubts, Mr. Whiteaves referred with doubt a shell that is probably congeneric with ours to *Martesia* (*Martesia ? carinifera*, Geol. Surv. Canada, Mes. Foss. part 1, p. 54, pl. ix, fig. 7.).

Parapholas mersa Stoliczska, from Cretaceous strata of Southern India, possesses all the generic characteristics of this shell (Palæontologia Indica, vol. iii, p. 24, pl. ii, fig. 7). It differs from this species too obviously to need minute comparison, but it may be mentioned that our shell is much more slender, its umbonal grooves more oblique, its front not so much impressed, and its basal accessory valve is shorter and sharply pointed in front instead of behind. Mr. Whiteaves was not able to learn anything concerning the accessory valves of his species. The presence of two umbonal grooves, together with its elongate form, would seem to indicate generic relation with our shell. In its specific characters it differs widely from all known species, except, perhaps, *Martesia cuneata* Meek & Hayden. Some examples apparently of this species, collected in the valley of the Yellowstone River by Mr. J. A. Allen, indicate that the full adult forms are a little more elongate than the type-specimens of that species, and in that respect, as well as in many details, they closely resemble our species. They have, however, only one umbonal groove. Another feature of close resemblance between that species and ours is the almost exact identity in shape, size, and position of the umbonal plate, and its division by a linear longitudinal suture in *both species*. It thus seems that the division of the umbonal plate is not a generic character, but I can hardly agree with Dr. Stoliczska that the shells having two umbonal grooves are not generically distinct from those with one.

Position and locality.—Cretaceous strata, probably of the age of the Colorado Group; Upper Kanab, Southern Utah, where it was collected by Maj. J. W. Powell.

GASTEROPODA.

Genus PALIURUS Gabb.

PALIURUS PENTANGULATUS (sp. nov.).

Plate 4, figs. 4 *a* and *b*.

Shell slender, somewhat strongly bent, very gradually tapering from the proximal to the distal end; longitudinal angles or carinæ five, prominent, subangular; intervening grooves broadly concave; internal cavity moderately large, circular in cross-section.

Full length unknown; the only example collected, which is apparently nearly full-length, 17 millimeters; diameter at the proximal end of the specimen 2 millimeters, at the distal end $1\frac{1}{5}$ millimeters.

This shell has much the aspect of a portion of the stem of a *Pentacrinus*, especially as to its pentangular cross-section, but it is destitute of the jointed structure of those bodies, and the circular internal cavity shows plainly its testaceous character. It seems evidently to belong to the same group to which Mr. Gabb gave the name *Paliurus*, although it is marked by five instead of by only three carinæ, as in the typical species.

I am much more inclined to think these shells are related to *Dentalium* than to the *Annelidæ*, to which Mr. Gabb referred the typical species. Therefore they are so classified in this paper.

Position and locality.—Strata of Cretaceous age, probably of the Fox Hills Group; Monument Creek, near Colorado Springs, where it was collected by Mr. W. H. Holmes.

Genus ANISOMYON Meek & Hayden.

ANISOMYON CENTRALE Meek.

Plate 9, figs. 1 *a*, *b*, *c*, and *d*.

Anisomyon centrale MEEK, 1872, An. Rep. U. S. Geol. Surv. Terr. for 1870, p. 312.
Anisomyon centrale WHITE, 1876, U. S. Expl. and Surv. West 100th Merid., p. 194, pl. xviii, f. 8.

"Shell depressed conical, somewhat wider than high; apex central, or very nearly so; slopes nearly equal all around, or with sometimes the anterior and sometimes the posterior side a little convex, and the others more nearly straight; aperture circular; surface apparently smooth, excepting obscure lines of growth, crossed by several irregular, diverging, obscure, radiating ridges, and more strongly defined furrows; the former being mainly on the posterior and the latter on the interior [anterior?] and lateral slopes.

"Breadth of largest specimen seen, 1.16 inches; height, about 0.95 inch.

"I have seen only two specimens of this species, and these are internal casts, with merely some fragments of the very thin shell remaining, while the extreme apex of both is broken away. The radiating furrows are rather distinctly defined on the anterior slope of the internal cast, while one (not apparently the middle one) is narrower and distinctly deeper than the others on each side of it, which latter are about twice as wide, shallow, and often somewhat divided by a small ridge down the center of each. On the posterior slope, one of the ridges is more strongly defined than the others, especially near the apex, and seems to correspond to the deeper furrows of the anterior slope, though not exactly opposite to it. The broken apex in one of the specimens looks as if it might have been curved a little backward, though in the other it evidently curved forward at the point, if I have rightly determined the relative sides. One of the specimens shows obscure traces of the oval muscular scar on each side, and these are connected across the side I regard as the anterior by a slender line, but the specimen being a little worn on the opposite or posterior side, I have been unable to make out the broader interrupted band that ought to pass around the posterior side if the species really belongs to this genus.

"This species will be readily distinguished from all of the others yet known from the far Western Cretaceous rocks by its conical form and elevated apex.

"*Locality and position.*—Box Elder and Colorado City, Colo.; Fox Hills Group of the Upper Missouri Cretaceous series."

The illustrations of this species on plate 9 were prepared by Mr. Meek a short time before his death. The specimens were collected by Mr. W. H. Holmes, and other specimens of the species have been discovered on Gallinas Creek, New Mexico, by Professor Cope, and published by the writer (*loc. cit.*). These are merely casts in indurated clay, and do not therefore correctly represent the natural proportions of the shell, because their height had been much reduced by vertical pressure. Still later, a few others were discovered by the writer west of the Rocky Mountains in Northwestern Colorado.

This species seems to be at least as distinct from any of other published forms as they are from each other, but specific variation in this genus is evidently very great. Indeed, I think one cannot examine the original types of the published species and the collections subsequently made, together with the original descriptions and illustrations given by Mr. Meek in the publications of the United States Geological Survey of the Territories, without entertaining serious doubts whether more than two or three out of the seven published species of this genus from the Cretaceous strata of the United States are well founded. It is also a fact worthy of note in this connection that all the American species hitherto published are from the same or nearly the same stratigraphical horizon.

Genus ACTÆON Montfort.

ACTÆON WOOSTERI (sp. nov).

Plate 7, figs. 9 *a*, *b*, and *c*.

Shell small, narrowly subovate; spire acute, moderately produced, but forming only about one-quarter of the length of the shell; sides of the spire little if any convex; spiral angle about 50°; volutions five or six, moderately convex, the last one not disproportionately inflated; suture distinct, the distal side of the volutions bending more abruptly into it than the proximal side; aperture narrow, distal end acutely angular, proximal end rounded and slightly subangular at the end of the columella; outer lip thin; inner lip a little thickened, especially along the proximal half of its length, upon which is apparently the moderately raised fold which characterizes the genus, but the condition of the only examples discovered do not show this feature clearly. Surface marked by numerous fine revolving lines, each alternate one being generally a little stronger than the other, but they are apparently otherwise of uniform size upon all portions of the surface. The examples are not in a condition to show whether these lines are punctate or not, but they probably were, as is usual in species of this genus.

Length, 13 millimeters; diameter, 6 millimeters; length of aperture, 7½ millimeters.

The only two examples of this species discovered were in the form of casts of the interior and partial molds of the exterior. The shells also are a little narrower than typical forms of *Actæon*, but the observable characters leave little doubt that the species is properly referable to that genus. It differs from *A. attenuatus* Meek & Hayden, from the Upper Missouri River country, in its much shorter spire, the lesser flattening of the sides of its volutions, especially the body one, and in the proportionally longer aperture. From *Solidula* [*Actæon?*] *riddelli* Shumard, from Texas (Proc. Bost. Soc. Nat. Hist., vol. viii, p. 194), it differs in the greater convexity of the spiral angle and in the much coarser and smaller number of revolving striæ. The specific name is given in honor of Mr. L. C. Wooster, to whom the Survey is indebted for the opportunity to examine interesting collections of fossils from Colorado, among which were fragments of this species.

Position and locality.—Fox Hills Group, Cretaceous; near the confluence of the Saint Vrains and South Platte Rivers, Northern Colorado, and also from the Rio San Juan, Southwestern Colorado. Collected by Mr. W. H. Holmes, artist and geologist of the Survey.

Genus ACTÆONINA d'Orbigny.

ACTÆONINA PROSOCHEILA (sp. nov.).

Plate 7, figs. 10 *a* and *b*.

Shell small, much involute, narrow, subterete, widest in front of the middle; spire very small and short; volutions four or five, flattened on the sides, which flattening is especially observable upon the last volution, the greater part of each of the others being successively covered by partial involution; suture distinct, not impressed upon its distal side, but the distal side of the volutions bend abruptly into the suture, giving that side of the volutions a shouldered appearance; aperture moderately large; distal portion very narrow; proximal portion moderately expanded, and its margin rounded from the outer border to the end of the columella, with which it forms an obtuse subangle; outer lip thin; inner lip flexous, somewhat thickened, especially along its proximal portion, where the flexure occurs.

The only example discovered is a cast from which the test has been almost wholly removed, but there are upon it indications that revolving lines thickly covered the whole surface. They are apparently somewhat coarser than those of the preceding species, *Actæon woosteri*, but nothing further concerning their character can be ascertained.

Length, 4½ millimeters; breadth at widest part, 6½ millimeters; length of aperture, 10½ millimeters; length of spire beyond the distal end of the aperture, nearly 4 millimeters.

This species seems to be a true *Actæonina*. In general aspect and surface-marking it resembles *Actæon attenuata* Meek & Hayden, which, as suggested by Mr. Meek, may be an *Actæonina*, but it differs conspicuously in its much shorter spire and more slender general form.

Position and locality.—Fox Hills Group; at the confluence of the Saint Vrains and South Platte Rivers, Northern Colorado, where it was discovered by Mr. W. H. Holmes, artist and geologist of the Survey.

Genus TURBONILLA Risso.

TURBONILLA (CHEMNITZIA) COALVILLENSIS Meek.

Plate 9, figs. 5 *a* and *b*.

Turbinella (Chemnitzia?) coalvillensis MEEK, 1873, An. Rep. Geol. Surv. Terr. U. S. for 1872, p. 505.

This species, together with some others, are included in this paper mainly for the purpose of publishing the illustrations of them which were prepared by Mr. Meek a short time before his death, and which he had no opportunity to publish. In most cases, little or no additional information concerning these species has been obtained, and therefore his descriptions and remarks alone are given as he originally wrote them.

"Shell elongate-conical; volutions ten or eleven, moderately convex, last one not much produced below, rounded or sometimes obscurely subangular around the middle; suture well defined; aperture rhombic-suboval, being angular above and apparently a little so below; inner lip slightly thickened, rather deeply arched, a little reflected and closely appressed below; outer lip thin. Surface ornamented by rather strong, simple, regular, nearly or quite straight, vertical ridges, crossed by regularly disposed revolving lines (about ten or eleven of the ridges and five

or six of the revolving lines being seen on each volution of the spire); while only the revolving lines are continued below the middle of the body-volution.

"Length of a large specimen, 1 inch; breadth, 0.40 inch; angle of spire, from 20° to 25°.

"None of the specimens of this species yet seen are quite perfectly preserved at the base of the aperture. Some of them look as if there had been a slight angularity there, while others, differing in no other respect, present appearances that leave room for doubt on this point. In some of its characters, this shell reminds one of the fresh-water *Goniobasis*, to which I was at one time much inclined to refer it, and I am hardly quite sure that it may not have to take the name *Goniobasis coalvillensis*. Many authors refer very similar shells to *Chemnitzia*, but it has not so large and produced a body-volution and aperture as the forms to which Mr. Conrad and Dr. Stoliczska proposed to apply that name. If found in any of the Paleozoic rocks, most geologists would refer it to *Loxonema* of Phillips. Whether or not the nucleus or apex of its spire was covered, as in the typical species of *Turbonilla*, I have been unable to determine. It is a far larger shell, however, than the species upon which that genus was founded.

"Specifically, this species seems to be related to *Turbonilla spillmani* Conrad (Journ. Acad. N. S., vol. iv, new series, pl. 46, fig. 28), but its vertical folds or costæ are straighter, less crowded and less numerous, while its revolving lines are smaller and more numerous. Its aperture also certainly differs in being decidedly more angular above, and probably somewhat so below. It may likewise be compared with *Scalaria mathewsonii* Gabb, from Cretaceous rocks of California, from which it differs in having less convex volutions, or less rounded aperture, less crowded vertical ridges, and more distinct and coarse revolving lines.

"*Locality and position.*—Coalville, Utah; from below the lowest heavy bed of coal at that locality. Cretaceous."

Genus PHYSA Draparnaud.

PHYSA CARLETONI Meek.

Plate 7, fig. 12 *a*.

Physa carletoni MEEK, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 508.

No other example of this species, besides the single type-specimen discovered by Mr. Meek, has ever been obtained. The following is his description, and the figure on plate 7 was drawn from the type-specimen:

"Shell rhombic-subovate, attaining a medium size; very thin; spire short and small; volutions about three, last one very large, or forming near nine-tenths the entire bulk of the shell; aperture unknown; surface showing rather obscure lines of growth.

"Length, 0.56 inch; breadth, 0.35 inch.

"The only specimen of this species I have seen is somewhat imperfect, and so connected with a portion of the arenaceous matrix that its aperture and columella cannot be seen. It seems to have most nearly resembled such recent species as *P. lordi* Baird in general form. I should not have attempted to name and characterize the species without seeing the columella and aperture, had it not seemed desirable to call attention to it as the first species of the genus hitherto found in the well-marked Cretaceous strata of this country.

"*Locality and position.*—Carleton's coal-mine, near Coalville, Utah, in

a Cretaceous bed, associated with *Unio*, *Cardium*, *Inoceramus*, *Anomia*, *Neritina*, and other marine and fresh-water shells."

Although this interesting locality has been twice visited by myself since Mr. Meek made his collections there, it was found impracticable to make any further collections on account of the discontinuance of mining operations there and the consequent falling-in of the excavated strata. Mr. Meek found them to contain a remarkable assemblage of marine, brackish-water, and fresh-water forms belonging to the following genera: *Inoceramus*, *Unio*, *Cardium*, *Cyrena*, *Anomia*, *Physa*, *Valvata*, *Neritina*, *Melampus*, *Eulima* [*Eulimella?*], and *Turritella*. A remarkable feature in this assemblage of fossils is the modern type of the fresh- and brackish-water forms, especially of the Pulmonate *Gasteropoda*, although they are certainly of Cretaceous age, and probably not much above the middle of the full Cretaceous series as developed in Western North America. The marine character of the Cretaceous strata above these fresh- and brackish-water forms is as well marked as that of those below them. The following are remarks by Mr. Meek (*loc. cit.* p. 445) in relation to the geological position and affinities of these interesting fossils, the remainder of which it is hoped will be illustrated in a subsequent paper:

"Here we have from beds certainly overlaid by more than 1,000 feet of strata, containing Cretaceous types of fossils, a little group of forms presenting such modern affinities that, if placed before any paleontologist unacquainted with the facts, they would be at once referred to the Tertiary. Such examples as this illustrate the difficulties with which the paleontologist sometimes has to contend, and show how very cautious we should be in deciding from the affinities of new species of fresh- and brackish-water types of shells (the vertical range of which is unknown) the geological age of the rocks in which they are found; because species of this kind, from rocks of various ages, often closely resemble each other, while they rarely present such well-marked distinctive features as we see in marine shells from different horizons. Some of the species of *Physa*, *Cyrena*, *Neritina*, &c., for instance, from the clays under consideration, closely resemble existing species, while one or two of *Melampus* present but very slight differences from Paris Basin Tertiary species figured by Deshayes under the name *Auricula*.

"It would appear that the indurated clay containing these mixed types of shells must have been deposited, in the form of fine mud, in an estuary, or possibly a larger body of salt water, into which the fresh-water shells were swept by streams flowing in from adjacent land."

This species, *Physa carletoni* Meek, is so nearly synonymous with *Physa carltonii* Lea as to deserve notice. The former was published (*loc. cit.*) in 1873, and the latter originally in Proc. Acad. Nat. Sci. Phila. p. 125, 1869, and subsequently in Lea's "Observations on the Genus Unio," vol. xiii, p. 67, pl. 21, fig. 19. The difference of the presence of the letter "e" in the former case is held to be sufficient to destroy its synonymy with the latter; besides which the two species are clearly distinct, and the names were given in honor, respectively, of two different persons.

PHYSA ——?

Plate 7, fig. 13 *a*.

From a stratum about 800 feet below that from which the foregoing species of *Physa* was collected by Mr. Meek, and at a locality about two miles distant, I discovered the example represented on plate 7, fig. 13 *a*. It is an imperfect cast in sandstone, and was found associated with forms

that are regarded as exclusively marine. It appears to be of the same general type as *Physa carletoni* Meek, just described, and may be specifically identical, but it is too imperfect to determine that point satisfactorily. Its chief value lies in the proof it affords of the contemporaneous near proximity of land, with its fresh waters containing a molluscan fauna; and in connection with other facts just recorded, it shows a long continuation of the existence of a shore-line there.

The locality from which this example was obtained is from the high ridge just northeastward from Coalville, Utah.

Genus NERITINA Lamarck.

NERITINA PISUM Meek.

Plate 7, figs. 11 *a*, *b*, and *c*.

Neritina (*Neritella*) *pisum* MEEK, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 500.

The following is Mr. Meek's original description of this species (*loc. cit.*), which is copied here, since no additional facts have been obtained concerning its characteristics and affinities:

"Shell globose; spire much depressed; volutions about three, increasing in size, so that the last or body turn (which is a little depressed above) composes nearly the entire shell; inner lip broad, flattened, and smooth; aperture small and semicircular; surface nearly or quite smooth.

"Height, 0.22 inch; breadth, 0.26 inch.

"*Locality and position.*—Coalville, Utah. Cretaceous; from below the lower bed of coal."

It is associated with *Neritina pisiformis* Meek, *N.* (*Velatella*) *patelliformis* Meek (also var. *weberensis* White), *Turbonilla* (*Chemnitzia*) *coalvillensis* Meek, *Turritella coalvillensis* Meek, and *Euspira coalvillensis* White. The strata containing these species appear to be from near the top of the Colorado Group, or near the base of the Fox Hills Group. This question cannot be decided satisfactorily, from the fact that the numerous species from all the strata of that interesting locality are mostly unique, and the lithological characteristics are such as to give little aid in the determination of the boundaries of the groups there represented.

NERITINA INCOMPTA (sp. nov.).

Plate 7, figs. 6 *a*, *b*, and *c*.

Neritina bannisteri (MEEK) White, 1876, Powell's Rep. Geol. Uinta Mts. p. 98.

Shell transversely elongate when adult; spire depressed, abruptly convex, small, but rising perceptibly above the body-volution; volutions three and a half or four, increasing rapidly in size, the last one comprising much the greater part of the shell, regularly convex or with a faint appearance of flattening upon the distal side of the last one; suture moderately distinct; aperture rather large, its outer border regularly rounded, proximal and distal margins slightly convex and subparallel; outer lip thin-edged; inner lip moderately long, plain, slightly concave upon its face, not very broad, sloping inward. Surface marked by ordinary lines of growth.

Length, in direction of the axis, 12 millimeters; breadth across the aperture and body-volution, 17 millimeters.

This species resembles *N. bannisteri* Meek from the brackish-water

layers of the same formation at Coalville, Utah; but it differs in the greater, although slight, elevation of the apex, the nearly straight, instead of curved, border of the inner lip, and its non-polished surface.

Position and locality.—Cretaceous strata, Fox Hills Group; valley of Sulphur Creek, near Hilliard Station, Union Pacific Railroad, Wyoming.

NERITINA (VELATELLA) PATELLIFORMIS Meek.

Plate 7, figs. 7 *a*, *b*, *c*, and *d*.

Neritina (*Dostia?*) *patelliformis* MEEK, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 498.

"Shell small, thick, oval or subelliptic; nucleus nearly posterior and generally more or less elevated above the posterior margin, but always lower than the middle portion of the dorsal region in front of it, directed obliquely backward, and in well-preserved specimens minutely subspiral at the immediate, more or less oblique apex; inner lip very broad, or having the form of a thick, smooth, convex septum that extends forward more than half the length of the shell; outer lip thickened, obtuse and smooth within; open part of the aperture small and transversely semicircular. Surface with moderately distinct lines of growth.

"Length of one of the largest specimens found, 0.62 inch; breadth, 0.50 inch; height or convexity, 0.33 inch."

This species belongs to an interesting group of Neritoid shells, for which Mr. Meek proposed or rather suggested the name *Velatella* (*loc. cit.* p. 499). It seems to be a well-defined group, as indicated by the external features common to its species; and also by the internal characteristics as described by me in Wheeler's Expl. and Surv. West of the 100th Merid. vol. iv, pt. 1, p. 189, discovered in a species then supposed to be identical with *N.* (*V.*) *carditoides* Meek, but which, from later comparisons, seems to belong to the following variety or perhaps to a distinct species.

At present there are four or five species of this group known, all but one of which occur in the Fox Hills Group, and the other at or near the summit of the Laramie Group. The species appear to have been in part of marine and part of brackish-water habitat. So far as I am aware, no other species of this type besides those here mentioned have ever been discovered; consequently no other comparisons need be made.

The typical forms of the species here described seem to be quite distinct from any of the other known species of the group, but by the following associated variety it appears to be connected with *N.* (*V.*) *carditoides* Meek, from the brackish-water Cretaceous layers, some 800 feet above the position of these, and at a locality some two miles distant.

"*Locality and position.*—Coalville, Utah, from the Cretaceous beneath the lower heavy bed of coal mined at that place."

NERITINA (VELATELLA) PATELLIFORMIS var. WEBERENSIS.

Plate 7, figs. 8 *a* and *b*.

Shell small, depressed, almost regularly elliptical in outline, nearly regularly convex above, and nearly flat or longitudinally slightly concave beneath; beak very small, apparently making about one volution, turned a little to the dextral side of the shell, resting upon the thickened posterior margin, but not projecting beyond it, the posterior margin being slightly reflexed so as to obscure the incurved apex; inner lip broad, smooth, flat, or concave longitudinally, and slightly convex

laterally, apparently occupying more than half the under surface of the shell; outer lip moderately thin, smooth, or at least not crenulate. Surface marked by ordinary lines and undulations of growth, and upon the middle portion of the anterior half by five or six narrow, slightly raised, obscure, radiating ribs, with spaces between them a little wider than the ribs. In some cases there are also other obscure radiating lines upon the anterior flanks of the shell.

Length, 11 millimeters; breadth, 8 millimeters; height, 5 millimeters. Some examples in the collection are larger, but none of them quite equal in size the larger examples of the typical forms of the species.

This variety, although perhaps connecting the typical forms with *N.* (*V.*) *carditoides* Meek, differs from it in the number and character of its costæ, the proportions of the shell, and its smaller size. At one time I thought, as did also Mr. Meek, that this variety might prove to be specifically distinct from the typical forms of *N.* (*V.*) *patelliformis*, but study of collections since made at the typical locality shows that intermediate forms exist, associated with this variety and the typical forms in the same layer.

"*Position and locality.*—Cretaceous strata, equivalent with the upper part of the Colorado Group or base of the Fox Hills Group, Coalville, Utah."

Genus EUSPIRA Agassiz.

EUSPIRA COALVILLENSIS White.

Plate 4, figs. 2 *a* and *b*.

Lunatia coalvillensis WHITE, 1876, Powell's Rep. Geol. Uinta Mts. p. 122.

Shell subglobose; spire small, conical, acute, but not much extended; volutions about eight when the apex is entire, last one inflated, and, when adult, extended a little in front, and also posteriorly, near the border of the aperture; aperture obliquely ovate-semilunar, somewhat abruptly rounded anteriorly; callus of the inner lip apparently not much thickened, but thicker anteriorly than posteriorly; columella rimate or almost solid and nearly covered by the callus of the inner lip, which seems not to be so closely appressed against it as it is against the body-volution farther back. Surface marked by the ordinary lines of growth. The figures on plate 4 are restorations of this species, all the numerous examples in the collections being crushed, except one or two sandstone casts. The examples being somewhat numerous afford a view of all the features shown by the figures.

Length, from the apex to the anterior end of the aperture, about 4 centimeters; breadth, across the aperture and body-volution, about 3½ centimeters.

In general aspect this species closely resembles *E. rotundata* Sowerby sp., as figured and described by Stoliczska (Palæontologia Indica, vol. II, p. 303, pl. xxi, figs. 9 and 9 *a*), but it differs in its somewhat more acute spire and more elongate aperture; and in some of our examples there is an extension of the apex of the spire similar to that shown by Stoliczska (*loc. cit.* figs. 7 and 8), in *E. pagoda* Forbes. Perhaps no generic distinction should be made between those Cretaceous forms which are usually referred to *Lunatia* and those which have been referred to *Euspira;* but for the present I prefer to retain the latter name for those forms which have a small prominent spire and less compact form than those shells have which are regarded as typical of *Lunatia.*

Position and locality.—Cretaceous strata, upper portion of the Colorado Group, or base of the Fox Hills Group; Coalville, Utah.

Genus ANCHURA Conrad.

ANCHURA HAYDENI (sp. nov.).

Plate 7, fig. 1 *a*.

Shell large; body, exclusive of the wing and including the beak, subfusiform; spire elongate, about equal in length to the body-volution and the beak together; volutions ten or twelve, moderately convex; those of the spire marked by longitudinal nodes, which disappear before reaching the suture at either side of the volution, but they approach more nearly to that of the proximal side; suture linear or faintly impressed; surface of the volutions of the spire marked by from five to seven strong revolving raised lines, which are of about equal strength upon and between the longitudinal nodes; numerous minute revolving raised lines also cover the surface between the stronger ones just mentioned, and these are crossed by numerous fine, sharply raised lines of growth, giving the well-preserved surface of the shell a finely cancellated appearance under the lens. Upon the body-volution, the longitudinal nodes gradually disappear and are replaced by a median row of smaller nodes, continuous with the former, and also with the strong plain carina which extends out upon the wing to its posterior extremity, and lies near to and nearly parallel with the posterior border of the wing. The stronger revolving lines of the spire become still stronger with the increase in size of the volutions, but they disappear upon reaching the wing. Four or five of those immediately in front of the median convexity of the body-volutions are especially strong, and become sharply raised ridges with channels of about equal width between them; in front of these is a series of smaller ones, the representatives of which are covered by the successive turns of the spire, and which terminate upon and at the base of the beak. Beak long, slender, straight, pointed. Wing large, projecting much beyond the aperture, constricted in the middle of its transverse portion, but expanding again beyond; the posterior part much extended and terminating in a long, somewhat strong, pointed process, which is angular along its back; the anterior portion of the outer part of the wing is prominent, projecting forward and abruptly rounded; posterior border deeply concave; exterior border nearly or quite straight; anterior border having a general concavity, but a sinuous outline. Outer surface of the wing more or less strongly wrinkled in the direction of the lines of growth. The direction of these wrinkles and of the lines of growth indicates that before the wing was fully formed the antero-exterior portion of the wing was less prominent than when adult. Inner lip apparently without a callus.

Length, from the point of the beak to the apex of the spire, upward of 10 centimeters; length of beak, 2½ centimeters; breadth of body-volution, including the wing, 6½ centimeters; diameter of body-volution, exclusive of the wing, 28 millimeters.

The characteristics of this species do not strictly correspond with the requirements of either the typical forms of *Anchura* Conrad or the subgenus *Drepanocheilus* Meek. From the former it differs in not having an anterior as well as a posterior pointed process to the wing, unless the blunt projection of that portion of the wing of this species may be regarded as a sufficient generic equivalent. From the latter it differs in having the long beak, which is characteristic of the typical forms of *Anchura*. This is much the largest species of *Anchura* known to me, and it differs too widely from any described form to need comparison. The

spire of nearly all the examples discovered were encrusted with a slightly compacted calcareous layer, which at first suggested the idea that it might be the remains of a callus such as covers the spire in *Lispodesthes* White and *Calyptraphorus* Conrad, but in this case it is probably a *Nullipora*. The specific name is given in honor of Dr. F. V. Hayden, the director of the Survey.

Position and locality.—Strata probably equivalent with the Fort Pierre Group, Cretaceous No. 4, of the Upper Missouri section; 15 miles west of Greeley, Colo., and about 6 miles south of Fort Collins.

ANCHURA (DREPANOCHEILUS) RUIDA White.

Plate 7, figs. 4 *a* and *b*.

Anchura ruida WHITE, 1876, Powell's Rep. Geol. Uinta Mts. p. 120.

Shell rather small; spire moderately elongate; volutions about seven, convex; suture impressed; wing moderately large, contorted, bearing at its extero-posterior corner a strong falciform process, the direction of which is nearly parallel with the axis of the shell; the outer border of this process is slightly convex and continuous with the outer border of the body of the wing; the extero-anterior border of the wing abruptly rounded, from which, to the very short beak, the border is sinuous, almost sigmoid; posterior border of the wing deeply concave, its proximal half being slightly reflexed outward, as if for the passage of soft parts corresponding to those that in allied genera occupy a posterior canal, as the curved sinus adjacent to the columella doubtless gave passage to soft parts corresponding to those that in *Anchura* proper occupied the anterior canal or channel of the beak; inner lip provided with a distinct and moderately broad callus, which, in some cases at least, extends beyond the distal end of the aperture across the next volution, as seen by dorsal aspect of the shell; columella very slightly produced in front, and its apex flexed a little toward the dextral side of the shell. Volutions of the spire marked by many longitudinally oblique folds, which extend to the suture on the proximal side of the volutions, but not much beyond the middle on the distal side, and do not appear at all on either the body-volution or wing. The whole surface marked by fine revolving striæ, which are more distinct upon the last volution than elsewhere; last volution and wing also marked by a moderately strong carina, which terminates at the point of the falciform process.

Length, 16 millimeters; breadth across the body-volution, including the wing, 12 millimeters.

This species agrees well with the subgeneric diagnosis of Meek for *Drepanocheilus*, and in many respects it resembles *A.* (*D.*) *americana* Evans & Shumard sp., but it differs from that shell in its large anterior sinus, the deep sinuosity of the anterior border of the wing, and the reflexion of a portion of the posterior margin of the wing.

Position and locality.—Cretaceous strata; Upper Kanab, Southern Utah. Collected by Prof. J. W. Powell.

ANCHURA (DREPANOCHEILUS) MUDGEANA (sp. nov.).

Plate 7, figs. 3 *a* and *b*.

Shell of medium size for one of the genus; spire moderately elongated; volutions about eight, convex; suture rather deep; body-volution proportionally large; wing proper rather small, recurved club-shaped, oc-

cupying only about one-third of the full length of the outer lip, blunt or abruptly rounded at the posterior end of the posterior projection, instead of being falciform, as is usual in this genus; outer lip, exclusive of the wing proper, moderately broad, prominent, sloping from the posterior base of the wing to the last suture, with a gently convex border, sloping with a very gently sinuous border from the anterior base of the wing to the pointed front of the shell; inner lip having a moderately broad, distinct callus, extending from the anterior end of the columella to or nearly to the last suture; aperture elongate, narrow. Volutions of the spire marked by many longitudinal folds, which are somewhat more oblique upon the smaller volutions than upon the larger, and extend almost or quite to the suture upon both the proximal and distal side of the volution. These folds are continued upon the body-volution, but are not extended upon its anterior half, and give place to smaller, irregular wrinkles upon approaching the outer lip. These wrinkles are smaller at the base of the wing, but upon the outer recurved portion they become conspicuously strong. The whole surface is marked by fine revolving, raised striæ, which, with the lines of growth, produce a more or less distinctly cancellated appearance. No true angulation or carination of either the volutions or the wing exists.

Length from the pointed front to the apex of the spire, about 29 millimeters; breadth across the body-volution, including the wing, 20 millimeters; breadth of the body-volution, from the callus of the inner lip to the outer surface, 9½ millimeters.

Few families of shells present greater difficulties in the way of a reasonably precise diagnosis of the genera which compose it than the *Aporrhaidæ*, an exemplification of which fact is afforded by the four species embraced in this paper. Possibly the species here described ought to be ranged under *Arrhoges* Gabb, as a subgenus of *Aporrhais;* but it has no posterior canal, and the only feature by which it materially differs from *Drepanocheilus* Meek is the blunt instead of pointed posterior extension of the wing, and the absence of a carina or any angulation of its dorsal surface. This peculiarity of the wing, indeed, distinguishes it from any published species of the section of the family to which it belongs.

Position and locality.—Cretaceous strata; Denison, Tex., where it was collected by Prof. B. F. Mudge, and in whose honor the specific name is given.

ANCHURA (DREPANOCHEILUS) PROLABIATA White.

Plate 7, fig. 2 *a*.

Anchura prolabiata WHITE, 1876, Powell's Rep. Geol. Uinta Mts. p. 121.

Shell rather above medium size, subfusiform; spire elongated and tapering to a point, with nearly straight sides; volutions nine or ten, convex, the last one proportionally a little more enlarged than the others, the distal margin of each narrowly appressed against the proximal side of the next preceding one at the suture; wing large, broad, its outer border nearly straight or slightly convex, its anterior extremity abruptly rounded to the broadly concave front margin; posteriorly the wing is divided into two somewhat broad, prominent, blunt processes directed backward and a little outward, the inner one of the two being the narrower, and occupying a position about midway between the spire and the extreme outer margin of the wing; posterior border of the wing concave between the spire and the extremity of the first process, and less

concave between the base of the first and the extremity of the outer process. Anterior canal and beak short; no posterior canal; inner lip apparently without a callus.

Surface of the volutions of the spire marked by numerous vertical or slightly oblique folds or ridges, which disappear upon the body-volution, its surface, like that of the wing, being marked with comparatively strong wrinkles of growth; the folds of the spire are crossed by numerous fine revolving, raised lines, which are hardly visible without the aid of a lens, except those adjacent to the sutures, which are stronger; these revolving lines are perceptible upon the body-volution, but are absent or obsolete upon the wing. No carina passes out from the body-volution to either of the processes of the wing, but the inner process is the more convex of the two, its convexity being continuous with the greater convexity of the body-volution.

Extreme length from the point of the canal to the apex of the spire, nearly 4½ centimeters; breadth across the wing and body-volution, 29 millimeters; diameter of the body-volution, 15 millimeters.

The difficulty of assigning the species of the *Aporrhaidæ* found in our Western Cretaceous rocks to rigidly defined genera has already been referred to, and this species not only presents no exception to that rule, but it possesses some unique features, notably that of a second expansion of the outer lip, and it is apparently without the usual sinuosity of the front margin near the columella. With these exceptions, it would conform well with the diagnosis of the subgenus *Drepanocheilus* Meek. It is, however, apparently without the callous inner lip possessed by all the species of that subgenus known to me. Its reference as above is of course provisional.

Position and locality.—Cretaceous strata, probably of the age of the Colorado Group; Upper Kanab and Sink Spring, Utah, where it was collected by Prof. J. W. Powell. I also saw examples of it from the same localities in the collection of Professor Barfut, Salt Lake City, Utah.

Genus TURRITELLA Lamarck.

TURRITELLA MARNOCHI (sp. nov.).

Plate 7, figs. 5 *a* and *b*.

Shell of usual size, elongate conical, gradually tapering, with slightly convex, nearly straight sides, apical angle from 20° to 25°, but varying somewhat in different specimens and in different portions of its length, in consequence of the slight convexity of the sides of the spire; volutions ten or twelve, flattened-convex, the last one rounded below; suture impressed, at the bottom of a moderately distinct channel; surface of the volutions of the spire marked by five (sometimes six) moderately elevated, revolving, nodulose carinæ, the distal one being a little larger than the others, and the nodules being sometimes so arranged as to form obliquely longitudinal rows across the volutions. These nodules appear, in some examples, to be a little elongated, the longer axes of those upon the carinæ that occupy the distal half of the volution being directed obliquely to the sinistral side of the shell, and the others to the dextral side; the surface between the carinæ marked by from three to five fine, raised, revolving lines; similar ones also marking the carinæ between the nodules. Besides the carinæ just described, visible upon the spire, there are several others of similar size, but a little more sharply raised, and a little less broken into nodules, on the proximal side of the last

volution. Fig. 5 *a*, plate 7, represents the natural exterior surface, while while fig. 5 *b* represents an exfoliated specimen.

Some of the examples show the carinæ to be more distinctly raised than they are in either of those that are figured, and less distinctly broken up into nodules.

The largest example in the collection, when entire, must have had a length of about 6 centimeters and a diameter of last volution, 19 millimeters.

This species resembles *T. corsicana* Shumard, also from Texan Cretaceous strata; but it differs from it in some important particulars, among which are its greater number of revolving carinæ, which are also less prominent and nodulose; in its revolving and convex, instead of flattened proximal surface of the last volution. It more nearly resembles *T. winchelli* Shumard, also from Texan Cretaceous strata, but differs in having a greater number of revolving carinæ and intervening raised lines, and also in the former being nodulose instead of smooth. The last volution of this species has at least eight carinæ, instead of only four, as in *T. winchelli.*

Position and locality.—Cretaceous strata; in the vicinity of Helotes, Bexar County, Tex., where it was collected by Mr. G. W. Marnoch, in whose honor the specific name is given.

TURRITELLA COALVILLENSIS Meek.

Plate 9, fig. 4 *a*.

Turritella coalvillensis MEEK, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 502.
Turritella coalvillensis WHITE, 1876, Powell's Rep. Geol. Uinta Mts. p. 98.

"Shell attaining a large size, elongate-conical; volutions apparently ten or more, distinctly convex, the most prominent part of those of the spire being somewhat below the middle, where they are angular; surface below the angle flattened, or a little concave, and sloping rather abruptly inward and downward to the suture, while above, to near the upper margin, where there is a shallow revolving concavity a little below the suture, it is convex; last volution probably biangular around the middle; suture well defined; aperture unknown. Surface ornamented by rather obscure revolving ridges, about five of which may be counted on each volution of the spire, one being at the lower margin immediately above the suture; another, which is also the largest, occupying the most prominent angular part of the whorl; and above this three others occur, one being above the revolving concavity and at the immediate upper margin; lines of growth obscure and making a strong backward curve in crossing the middle of the volutions.

"I have not seen specimens of this fine species sufficiently well preserved to be able to give accurate measurements, though those I have had an opportunity to examine indicate a length of not less than two inches and a fraction, and a breadth of 0.93 inch. The angle of its spire, as taken from near the middle of a large specimen, imperfect at both extremities, measures about 23°, while smaller individuals, composed of five or six of the upper volutions, show an angle of nearly 30°. It is, therefore, evidently a large robust species, that increases rather rapidly in size from the apex.

"*Locality and position.*—Coalville, Utah. From the Cretaceous, beneath the lower heavy bed of coal."

This and the five following species are all associated together in the same layer at Coalville, except the third, which is from layers somewhat

higher, and, so far as I am aware, none of them, except perhaps the *Eulimella*, have yet been discovered elsewhere. The stratigraphical position appears to be either at the top of the Colorado Group or near the base of the Fox Hills Group, or the equivalent of Nos. 4 and 5 of the Upper Missouri Cretaceous section.

TURRITELLA (ACLIS?) MICRONEMA Meek.

Plate 9, fig. 8 *a*.

Turritella (*Aclis?*) *micronema* MEEK, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 504.

"Shell small, terete or elongate-conical; volutions about nine, nearly flat, sometimes moderately convex, increasing gradually in size, last one rounded or obscurely subangular in the middle; suture linear to moderately distinct; aperture rhombic-ovate, angular above. Surface ornamented by fine, regular, rather crowded, revolving lines, six or eight of which may be counted on each volution of the spire.

"Length of the largest specimen seen, 0.50 inch; breadth, 0.18 inch; angle of spire, about 19°, with slightly convex slopes. [Specimens since found at the original locality, and in the same layers, indicate a size nearly twice as great as this.]

"This may not be a *Turritella*, the specimens not being in a condition to show the texture of the shell or to give a clear idea of its aperture and lip. It would be a rather small species for that genus, and if it possessed the delicacy of surface seen in those genera, it might perhaps with more propriety be referred to *Aclis* or *Menestho*. The fractured lip in some of the specimens has somewhat the appearance of a slight angularity or very small notch at the base of the aperture, but this may be due to the manner in which it is broken; if not, it would seem to present affinities with the genus *Mesalia*. It will be readily distinguished from the species I described under the name *T. spironema* by its less attenuated form and finer and less distinct revolving lines. It is also not nearly so attenuated toward the upper part of the spire as that species.

"*Locality and position.*—Coalville, Utah, from the Cretaceous below the heavy bed of coal mined at that place."

Genus EULIMELLA Forbes.

EULIMELLA? FUNICULA Meek.

Plate 9, fig. 10 *a*.

Eulima funicula MEEK, 1873, An. Rep. U. S. Geol. Sur. Terr. for 1872, p. 506.
?*Eulimella funicula* WHITE, 1876, U. S. Expl. and Surv. West of 100th Merid. vol. iv, p. 197, pl. xviii, fig. 6.

"Shell subterete or elongate-conical; spire regularly tapering from the middle of the body-volution to the apex, or with very slight convex slopes; volutions about twelve, flattened; last turn not much enlarged, subangular around the middle; suture merely linear; aperture ovate or rhombic-subovate; inner lip slightly thickened and reflected. Surface smooth.

"Length, 0.65 inch; breadth, 0.20 inch; divergence of slopes of spire, about 19°.

"This shell has much the appearance of a slender *Nisso*, but it certainly wants the umbilicus seen in that genus, its axis not being in the slightest degree perforated. It is even more like some recent species of

Eulimella, and may possibly have to take the name *Eulimella funicula*, when its generic characters can be more clearly determined from the examination of good specimens. The best examples I have seen do not show the extreme apex of the spire, or very clearly the form of the aperture. So far as can be determined, however, its columella does not seem to present the straightness seen in *Eulimella*. I know of no closely allied Cretaceous species.

"*Locality and position.*—Cretaceous, at Coaville, Utah."

The examples described and illustrated by me (*loc. cit.*) were published before I had seen either Mr. Meek's types or his drawings, having had access only to his published description. Subsequent comparison raises a doubt as to their specific identity, but they are evidently congeneric. My examples were more robust than Mr. Meek's, with a wider apical angle. It is possible that neither of these forms should be referred to *Eulimella*, but they certainly agree more nearly with the characteristics of that genus than with any other, so far as they are yet known.

Genus FUSUS Lamarck.

FUSUS (NEPTUNEA ?) GABBI Meek.

Plate 9, fig. 9 *a*.

Fusus (Neptunea ?) gabbi MEEK, 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 504.

"Shell rather small, fusiform; spire moderately prominent, conical; volutions seven or eight, convex; last one somewhat ventricose in the middle, and rather suddenly contracted below into the narrow, slightly twisted, more or less bent, and apparently moderately produced canal; suture well defined; aperture rhombic-subovate, and rather suddenly narrowed into the canal below. Surface ornamented with equal, distinct, regularly disposed varices or vertical folds, about eight of which may be counted on the penultimate volution, and less on the body-whorl, where some of them become obsolete; crossing these are also seen fine revolving lines, and, a little below the suture, apparently a shallow revolving furrow, that gives it a slightly banded appearance.

"Length, including canal, about 0.87 inch; breadth, 0.40 inch; slopes of spire straight, and diverging at an angle of about 50°.

"The specimens of this species contained in the collection are quite imperfect, being mainly casts retaining more or less of the shell. From such material it is, of course, impossible to determine with much confidence the generic affinities of shells. I have, therefore, provisionally referred it to the genus *Fusus*, putting in parenthesis the name *Neptunea* with a mark of doubt, to indicate that I suspect it may belong to that group, with the limits assigned it by some conchologists. It seems, however, quite as probably to belong to *Tritonidea*, as understood by some.

"*Locality and position.*—Coalville, Utah; from Cretaceous beds below the lower heavy bed of coal mined at that place."

Genus ADMETOPSIS Meek.

ADMETOPSIS RHOMBOIDES Meek.

Plate 9, figs. 6 *a* and *b*.

Admete ? rhomboides MEEK, 1873, An. Rep. U. S. Geol. Sur. Terr. for 1872, p. 501.

"Shell rather small, rhombic-suboval, or short-fusiform, the length being slightly more than twice the breadth at the widest part, which is

near the middle; spire rather depressed-conical, subturreted; volutions five or six, convex; last one forming about three-fourths of the entire bulk of the shell, and more than half its length, widest near its upper part, and abruptly narrowed below, so as to present an obliquely obovate form; suture rather deep from the convexity of the volutions; aperture narrow, subangular above, and narrowed below to a small notch at the base of the truncated columella, which is provided with two small, obscure plaits or folds, the lower of which is formed by the twisted margin of the truncated inner lip, while the other is placed a little farther up; outer lip sharp, with its margin slightly retreating above, and more prominent below, or near the middle. Surface ornamented with distinct vertical folds that are usually well developed on the volutions of the spire, and around the upper part of the body-whorl, but become obsolete below; moderately distinct revolving lines also mark the lower part of the body-volution, but these appear to become obsolete on its upper part, and on those of the spire, as specimens are usually found.

"Length, 0.37 inch; breadth, 0.21 inch; angle of spire, about 58°.

"I am much perplexed in regard to the proper disposition to make of this and the first two of the following species. In some of their characters they would seem to be related to certain types of the *Mitrinæ*, such as *Vulpecula* Blainville (= *Vulpecula* Klein), while in others they appear to have affinities to the *Cancellariidæ*, being much like the genus *Admete*. Without being at all satisfied, however, that they belong properly to the latter genus, I have concluded to refer them to it provisionally for the present until better specimens can be obtained for study and comparison. My present impression is that they will prove not to belong to any of the established genera, when all their characters can be clearly made out. If it should be found desirable, however, to establish a new group for their reception, I would propose for it the name *Admetopsis*, from the resemblance of the shell to the typical forms of the genus *Admete*.

"*Locality and position.*—Coalville, Utah; from Cretaceous beds beneath the lower heavy bed of coal at that place."

A careful comparison of these fossil forms, together with some obtained by one of Lieutenant Wheeler's surveying parties from the north fork of Virgin River, Utah, and others obtained from near Cedar City, Utah, with typical living forms of *Admete*, satisfied me that they are worthy of at least subgeneric separation from the last-named genus. Accordingly, I so referred a form in my report to Lieutenant Wheeler, which I then regarded as identical with *Admete? gregaria* Meek, but which is perhaps specifically distinct (U. S. Expl. and Sur. West of 100th Merid. vol. iv, p. 198, pl. xviii, figs. 5 *a* and *b*). I am now much inclined to regard these forms as generically disitnct from *Admete*, and so rank them in this paper.

The figures of this species on plate 9 were drawn by Mr. Meek, and he had written the name "*Admetopsis rhomboides*" under the figures.

ADMETOPSIS SUBFUSIFORMIS Meek.

Plate 9, fig. 7 *a*.

Admete? subfusiformis MEEK 1873, An. Rep. U. S. Geol. Surv. Terr. for 1872, p. 502.

"Shell subfusiform, with the length nearly three times the breadth; spire elongated, conical, turreted; volutions seven or eight, convex; last turn more than half the entire length; suture well defined in consequence of the convexity of the whorls; aperture narrow, equaling about two-fifths the entire length of the shell, angular behind and narrowing

below to a small, sharply defined notch at the base of the truncated columella, which seems to bear two small folds near its lower part, one being formed by the twisted and truncated lower margin; inner lip a little thickened; surface ornamented by distinct, regular, vertical folds that are nearly or quite obsolete on the body-volution below its upper part, and regular revolving lines quite well defined on the body-turn, especially its lower part, and appear to be obsolete on those of the spire; lines of growth moderately distinct.

"Length, 0.50 inch; breadth, 0.20 inch; angle of spire about 30°.

"This species differs even more strongly from the last [*A. gregaria*] than that form does from the species *rhomboides*, having a much more elevated spire and a proportionally smaller body-volution and aperture. In ornamentation, however, the three forms are much alike. The species here under consideration shows a somewhat more thickened inner lip than I have yet seen in either of the others.

"For the reasons already explained, this and the last may have to take the name *Turricula gregaria*, *T. subfusiformis*, if all three do not, as suggested back, require to be grouped together as a new section, under the names *Admetopsis rhomboides*, *A. gregaria*, and *A. subfusiformis*.

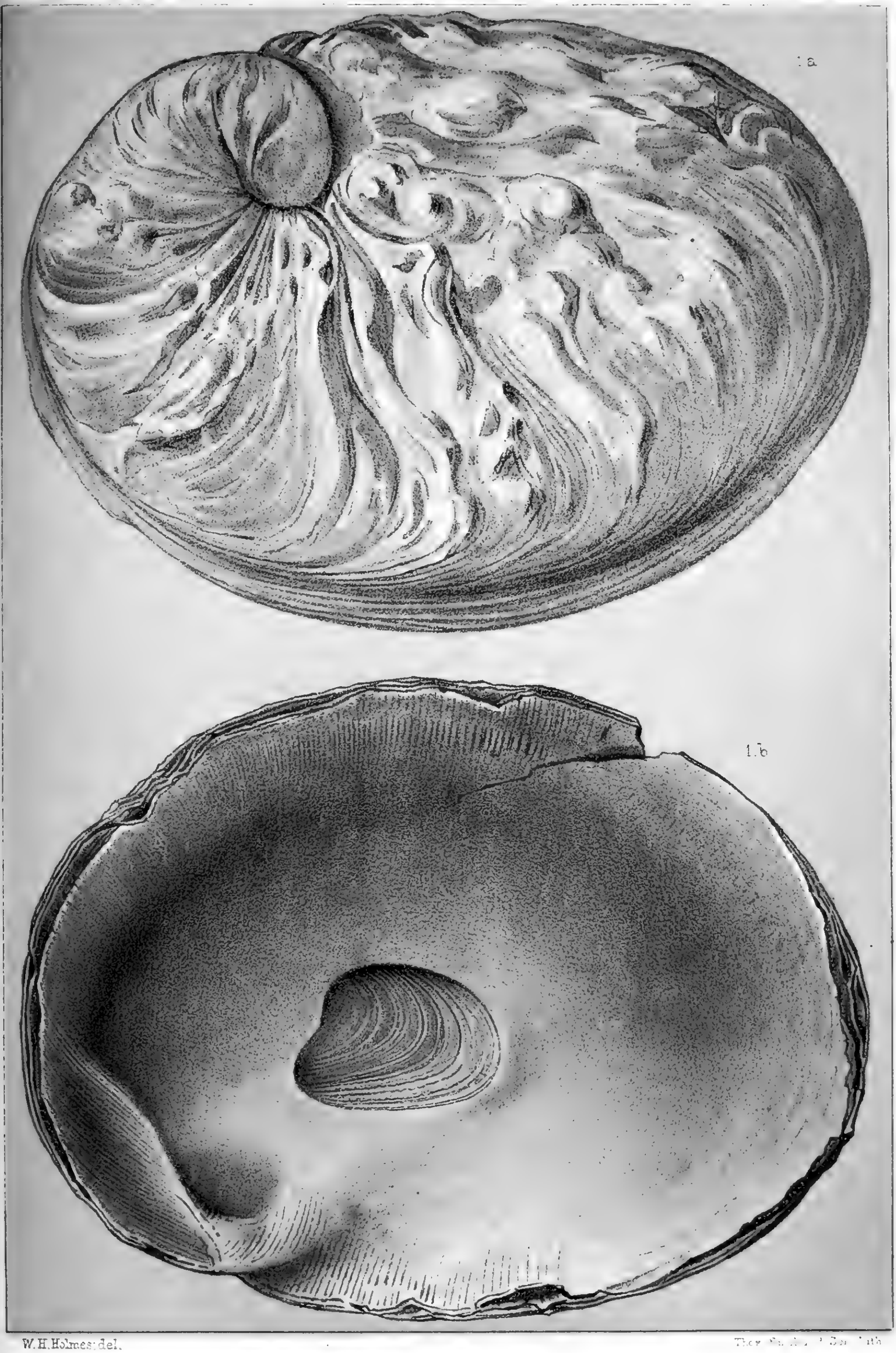
"*Locality and position.*—Same as last."

The figure illustrating this species on plate 9 was drawn by Mr. Meek, and he had written the name *Admetopsis subfusiformis* under the figures. All three of these forms are associated together in the same layers, and after examining many examples I am much inclined to think that they represent not more than two species at most. As to their generic relations, see remarks following the description of the last species. Figure 5 *a*, plate 3, represents a specimen from near Cedar City, Utah, which Mr. Meek had identified as belonging to his *A. gregaria*. I have not been able to find his type of that species among the collections, but judging from his description and collections which I have made from the typical locality at Coalville, Utah, I am not disposed to regard *A. gregaria* as distinct from *A. rhomboidea*. I therefore use the name for both these forms that comes first in the order of his descriptions.

PLATE 1.

		Page
FIG. 1. EXOGYRA VALKERI	....	278

a. Exterior of lower valve; diameter reduced one-quarter.
b. Interior of the same.



W. H. Holmes, del. Thos [illegible] lith.

PLATE 2.

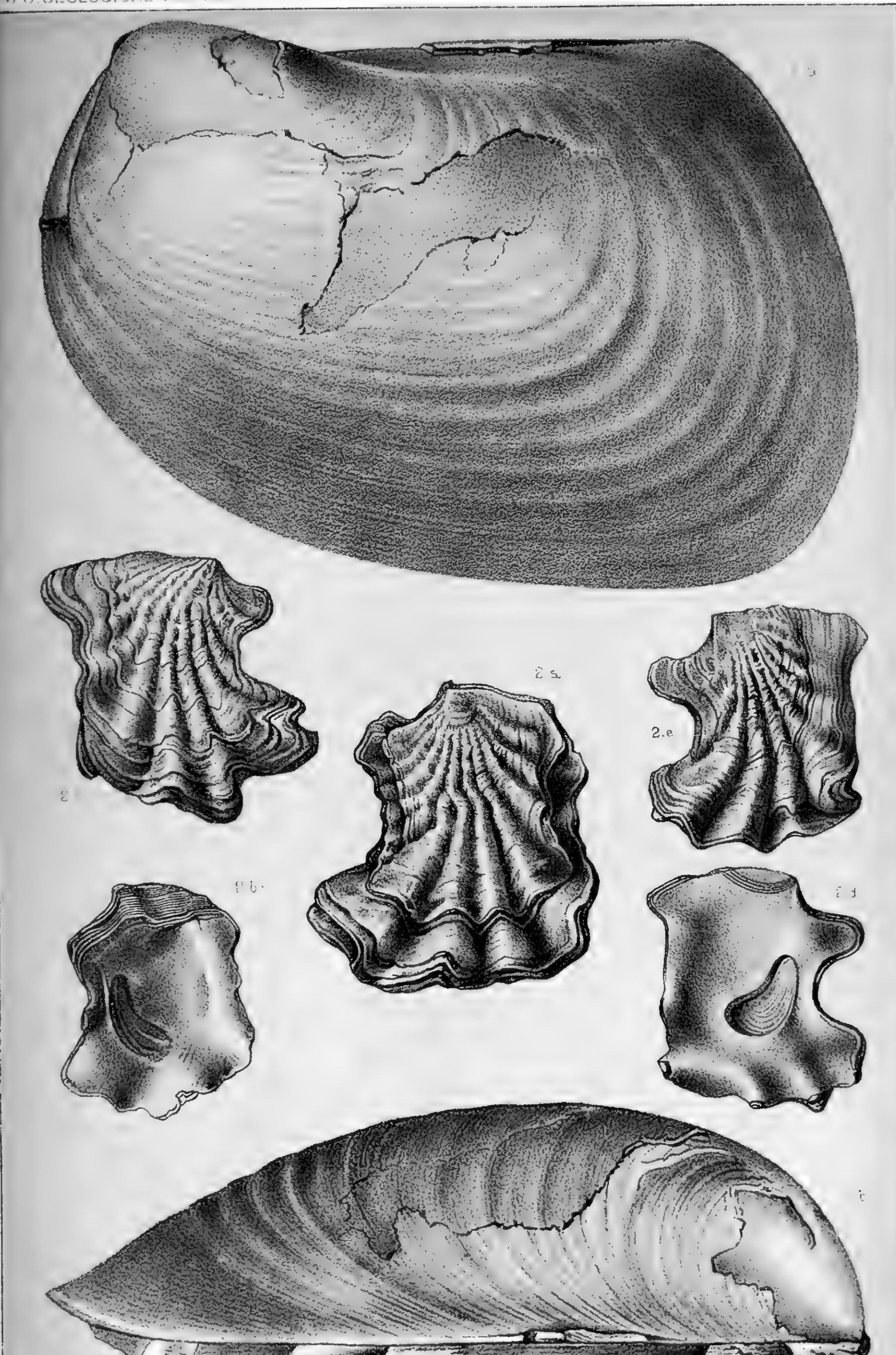

2.a
2.e

PLATE 3.

Page.

Fig. 1. Inoceramus gilberti 285

a. Right valve; test removed.
b. Front view of the same.
c. Left valve of another shell. All natural size.

Fig. 2. Cyrena securis 289

a. Right valve.
b. Dorsal view of shell.
c. Front view of the same. Natural size.

Fig. 3. Pteria parkensis 279

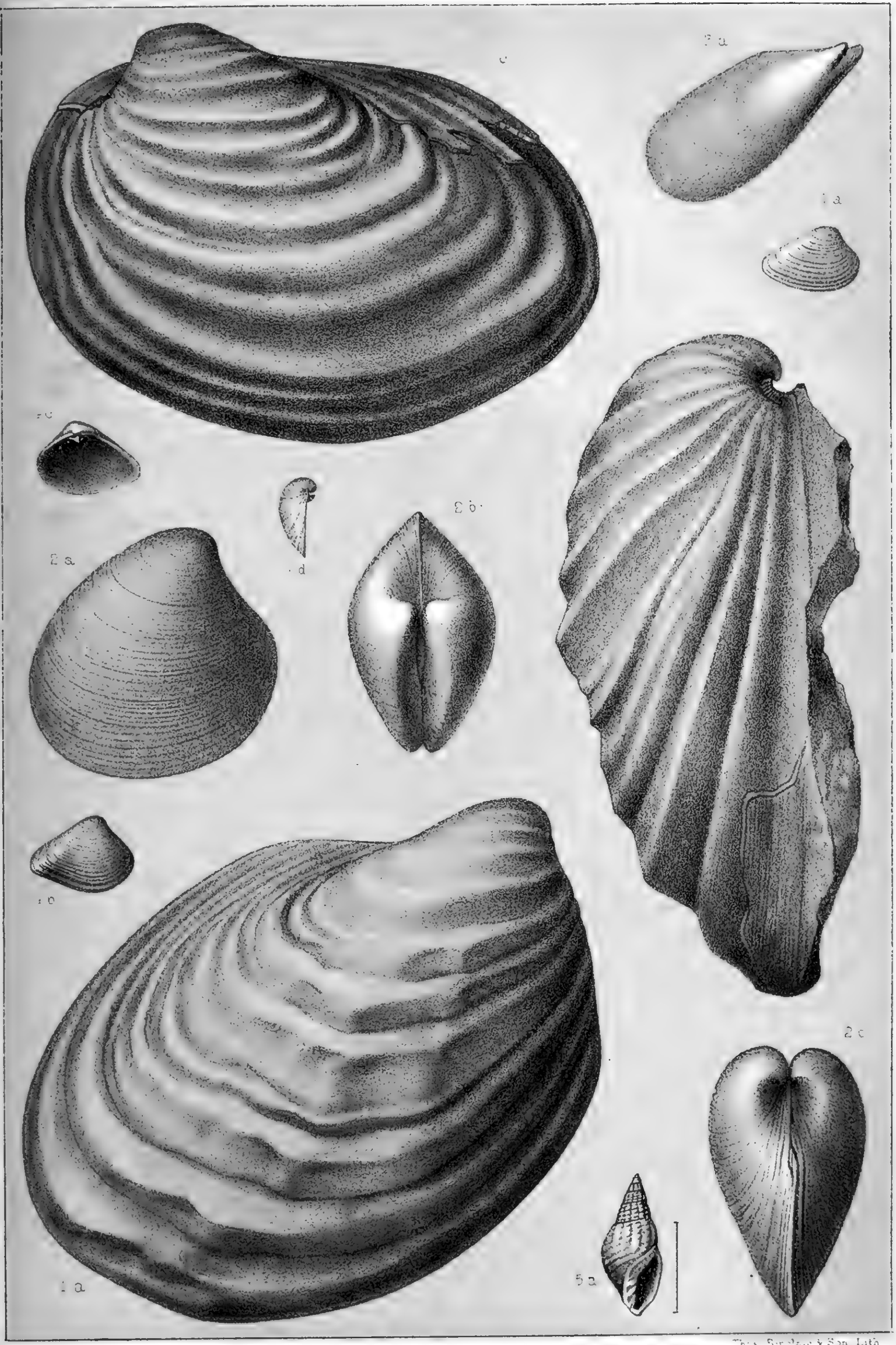
a. Side view of internal cast of right valve. Natural size.

Fig. 4. Corbula nematophora 290

a. Mr. Meek's type, right valve, natural size.
b. Right valve of an example identified by Mr. Meek, from Coalville, Utah. Natural size.
c. Interior view of the same, showing the hinge.
d. Front view of the same.

Fig. 5. Admetopsis gregaria 318

a. Apertural view of a specimen from near Cedar City, Utah; identified by Mr. Meek; enlarged one and a half diameters.



W. H. Holmes, del. Thos. Sinclair & Son, Lith.

PLATE 4.

Page.

FIG. 1. INOCERAMUS HOWELLI 284

a. View of right side; test removed.
b. Front view of the same.
c. Left valve of another example. All natural size.

FIG. 2. EUSPIRA COALVILLENSIS 310

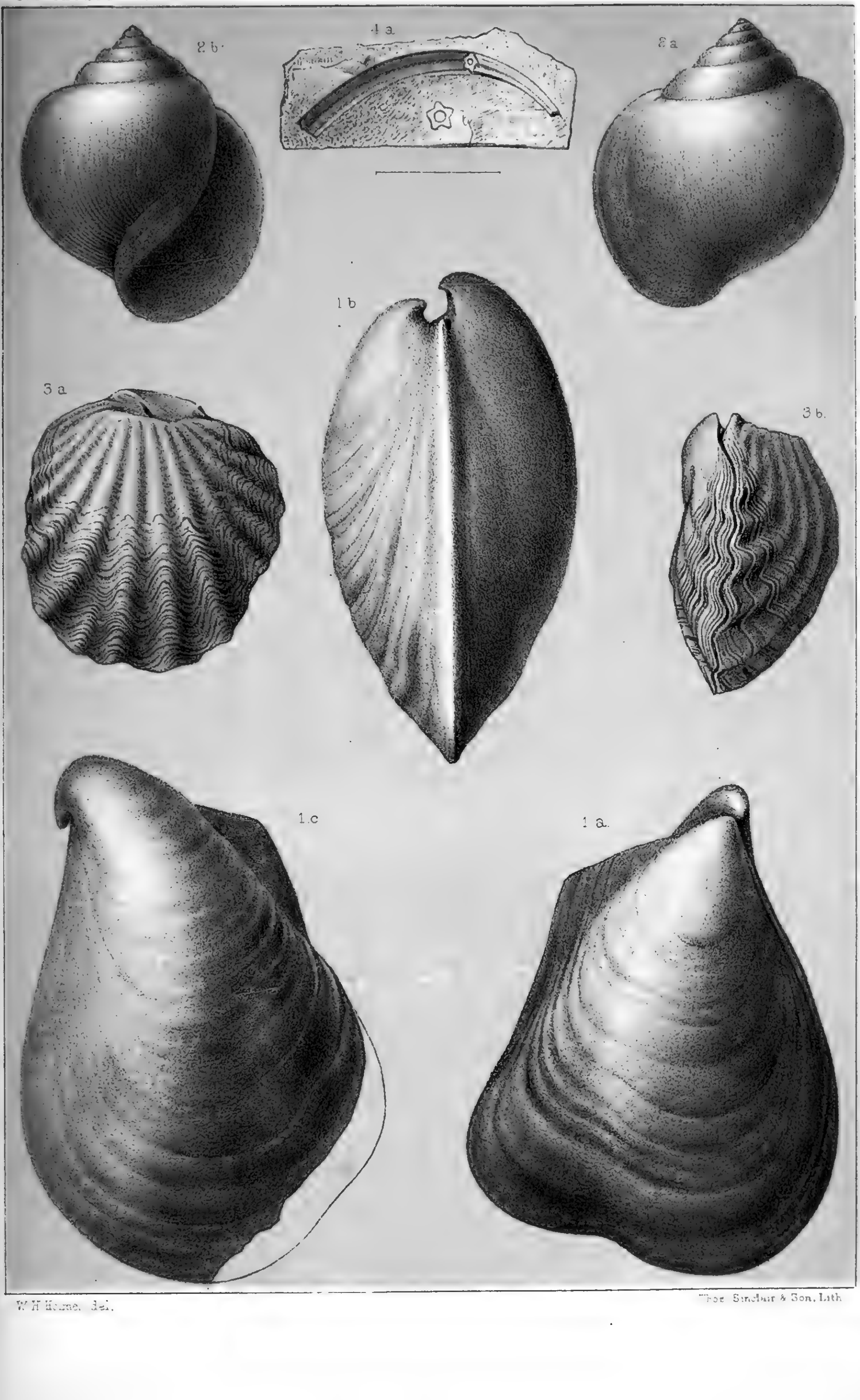
a. Side view; restored from several more or less imperfect examples.
b. Apertural view of the same. Natural size.

FIG. 3. OSTREA (ALECTRYONIA) BELLAPLICATA 276

a. View of the convex valve.
b. Side view of the same example. Natural size.
See, also, PLATE 8, figs. 2 *a* and *b*.

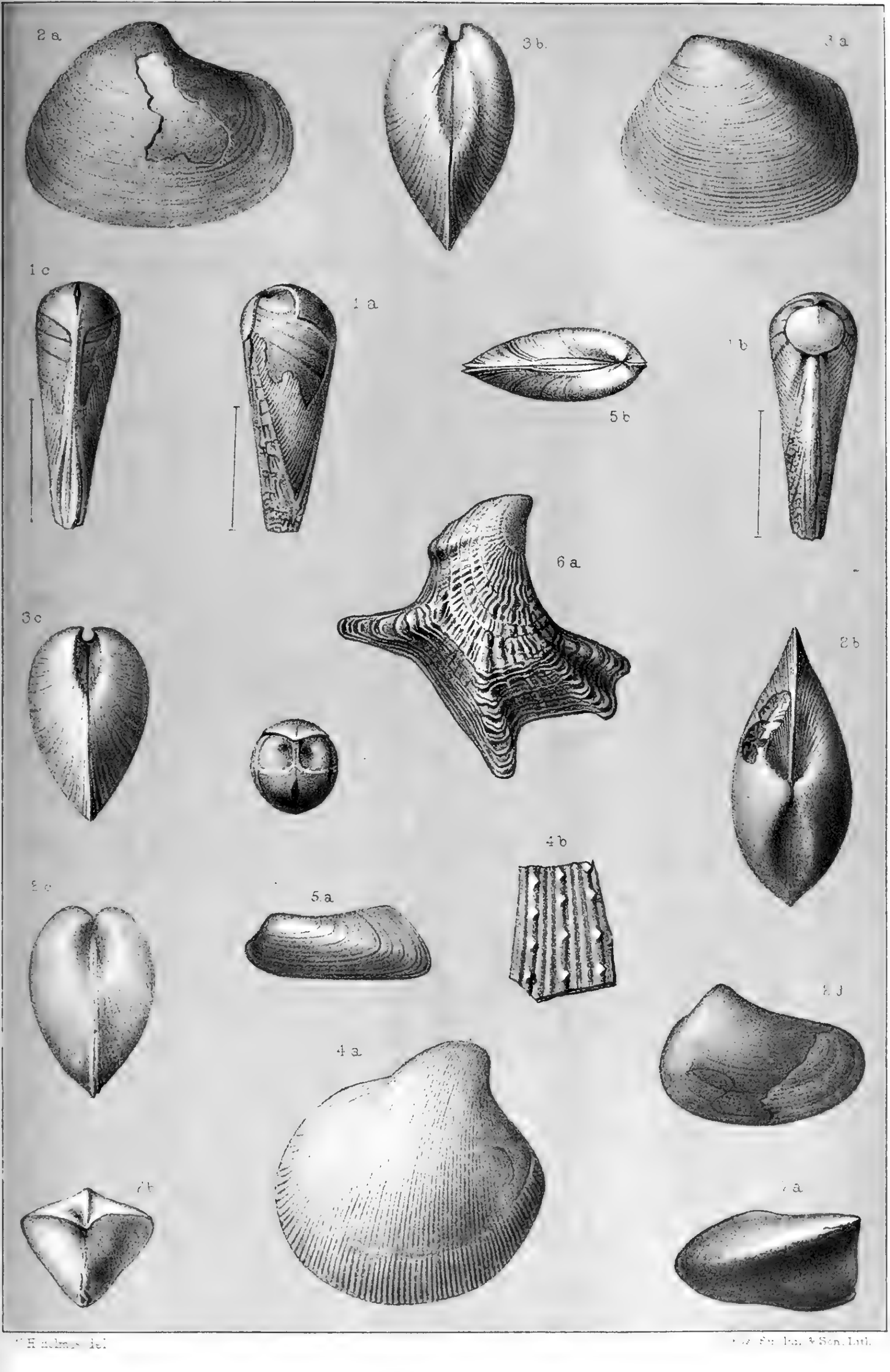
FIG. 4. PALIURUS PENTANGULATUS 302

a. Side view of broken example; showing also the matrix of the missing portion.
b. Transverse section of the same. Enlarged.



W. H. Holmes, del. Thos. Sinclair & Son, Lith.

PLATE 5.



H. Holmes del. Sinclair & Son. Lith.

PLATE 6.

Page.

Fig. 1. Glycimeris berthoudi 299

a. Left-side view; natural size.
b. Dorsal view of the same example.

Fig. 2. Barbatia coalvillensis 286

a. Exterior view; left valve; natural size.
b. Interior view, showing hinge, the middle portion of which is imperfect. Both are partial restorations.

Fig. 3. Plicatula hydrotheca 279

a. Natural cast in sandstone of the deeper valve; natural size.
b. External view of the upper or flat valve.

Fig. 4. Mactra? holmesii 295

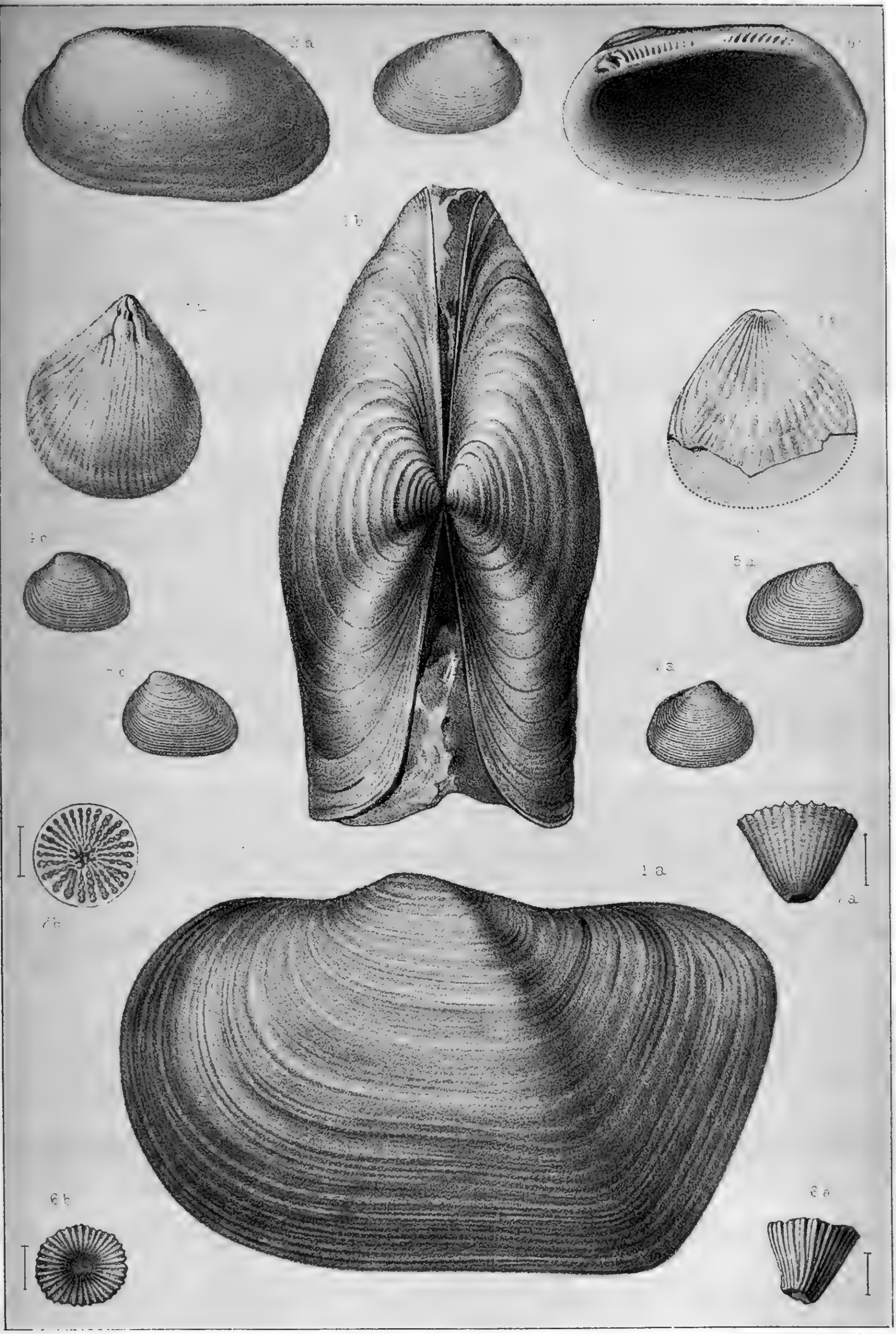
a. Right valve; natural size.
b. Left valve.
c. Side view; type-specimen.
Fig. 5, *a* and *b*; represent probably the same species; from near Cañon City, Colo.

Fig. 6. Caryophyllia johannis 274

a. Side view; enlarged two diameters.
b. Calycular view of the same.

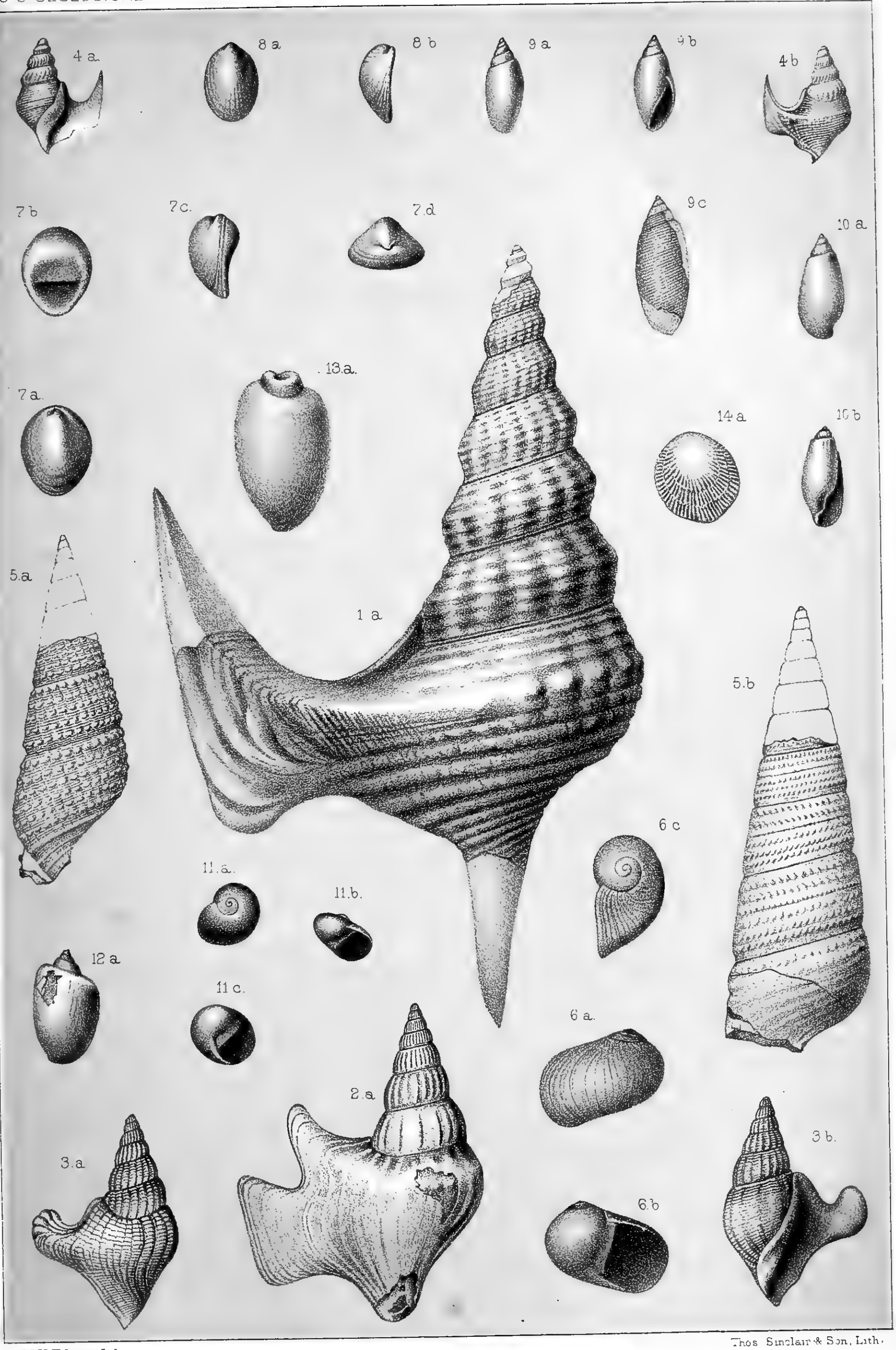
Fig. 7. Caryophyllia? egeria 275

a. Side view; enlarged two diameters.
b. Vertical view of another example, broken across just below the calyx.



W.H.Holmes, del.

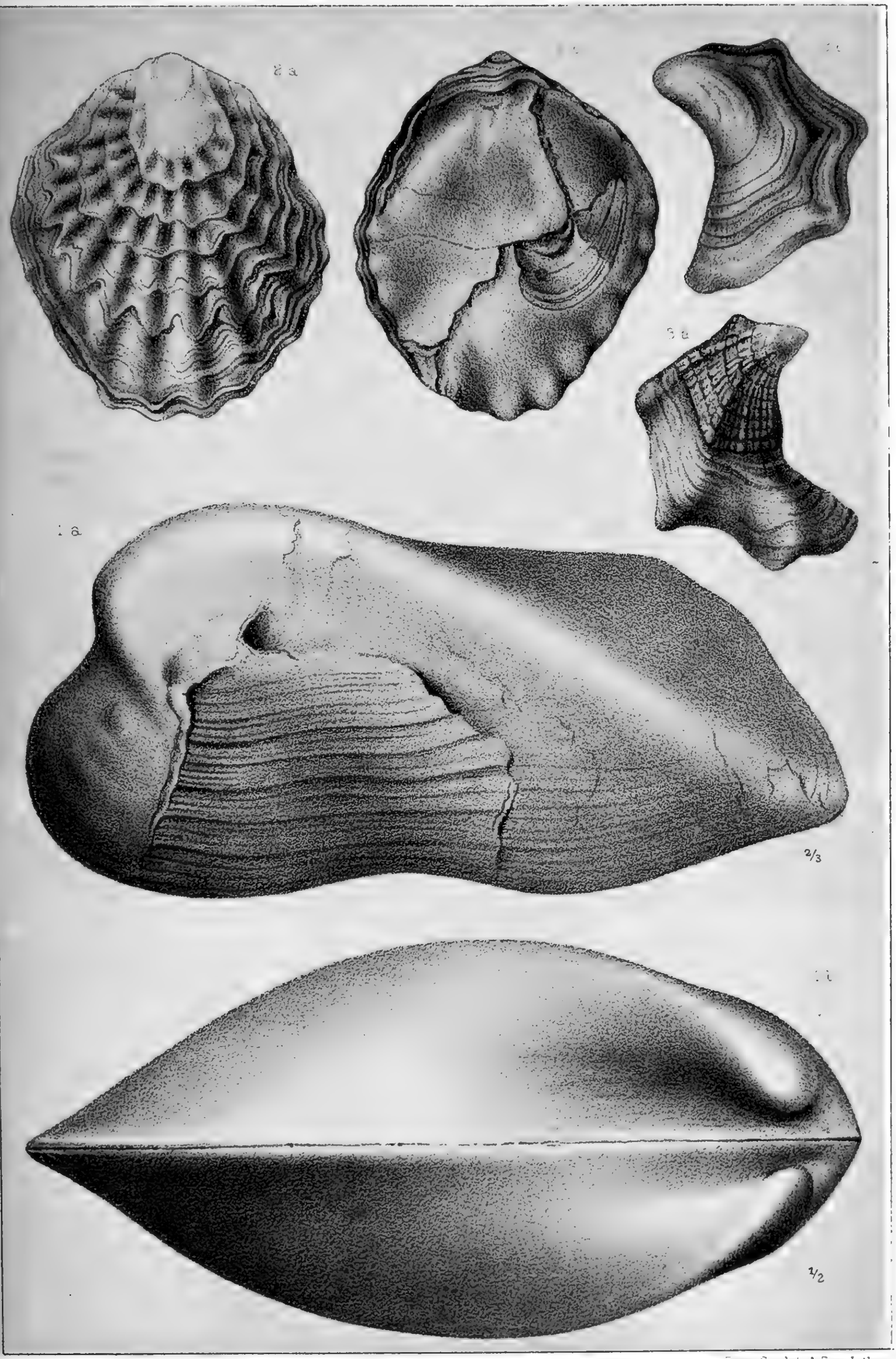
PLATE 7.



W. H. Holmes, del. Thos. Sinclair & Son, Lith.

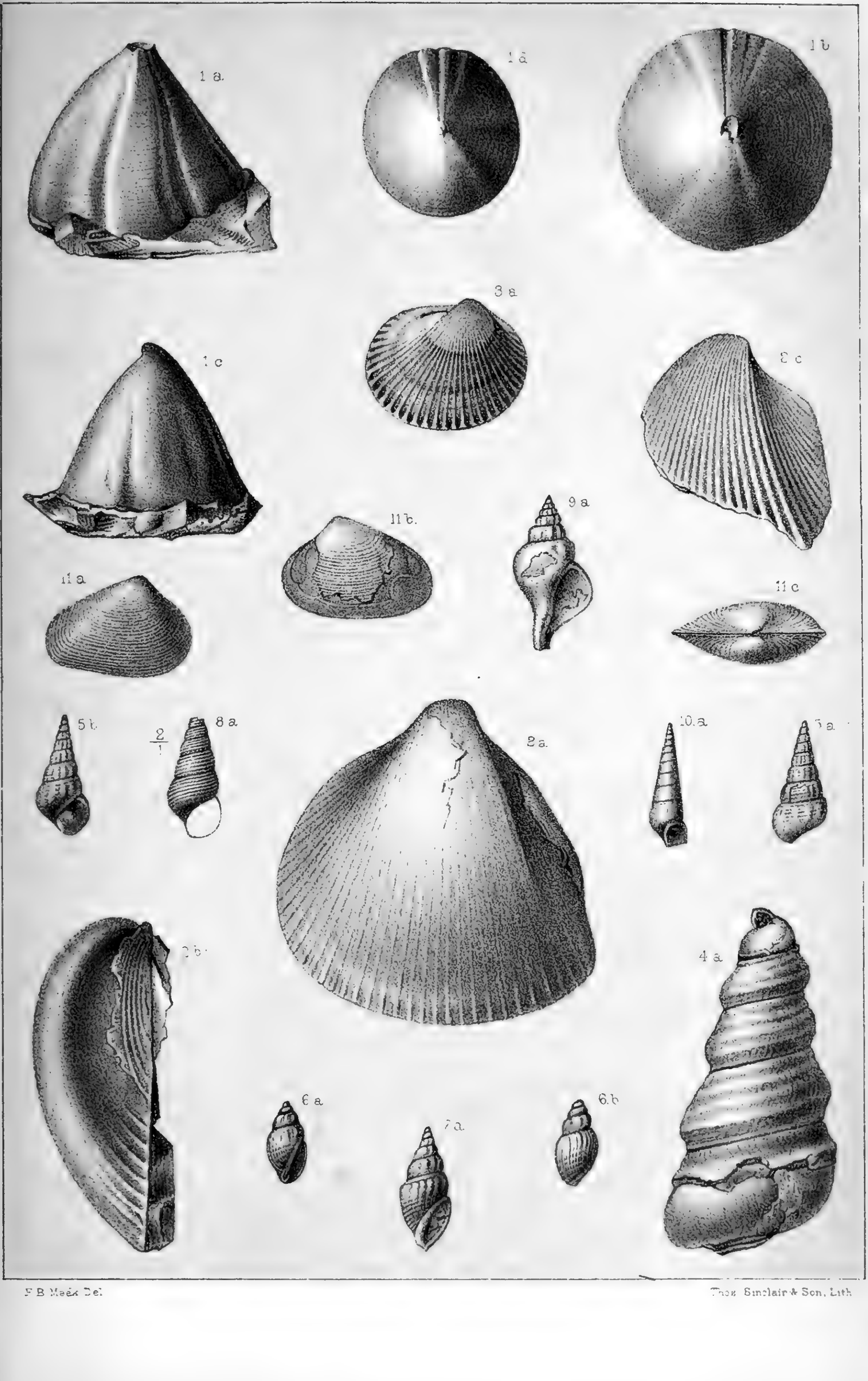
PLATE 8.

	Page.
FIG. 1. PACHYMYA AUSTINENSIS	298
a. Left valve, reduced to two-thirds of the natural diameter, from Dr. Shumard's figure.	
b. Natural cast; dorsal view; reduced one-half of the natural diameter from a specimen from Salado, Tex.	
See, also, PLATE 5, figs. 7 *a* and *b.*	
FIG. 2. OSTREA (ALECTRYONIA) BELLAPLICATA	276
a. Exterior view of upper valve; natural size.	
b. Interior view of the same. From photograph copies of Dr. Shumard's original figures.	
See, also, PLATE 4, figs. 3 *a* and *b.*	
FIG. 3. OSTREA QUADRIPLICATA	275
a. Lower valve; natural size.	
b. Upper valve. Both from photograph copies of Dr. Shumard's original drawings.	
See, also, PLATE 5, fig. 6 *a.*	



Sinclair & Son, Lith.

PLATE 9.



F B Meek Del. Thos. Sinclair & Son, Lith.

PLATE 10.

Page.

FIG. 1. PTERIA (OXYTOMA?) GASTRODES 280

a. View of sandstone cast of left valve; natural size.

FIG. 2. PTERIA (PSEUDOPTERA) PROPLEURA 281

a. Left valve of young example; front margin not quite perfect.
b. Left valve of a somewhat larger example.
c. Left valve of adult example; drawn from a gutta-percha cast of the sandstone mould of Mr. Meek's type-specimen of his *Avicula* (*Pseudoptera*) *rhytophora.*

FIG. 3. BARODA WYOMINGENSIS 293

a. Left valve; natural size.
b. Dorsal view of the same example.

FIG. 4. BARODA SUBELLIPTICA 294

a. Lateral view; left valve; natural size.
b. Dorsal view of the same, showing dorsal aspect of the teeth.
c. Right side view of a smaller example.
d. Dorsal view of the same.

FIG. 5. TRAPEZIUM MICRONEMA 293

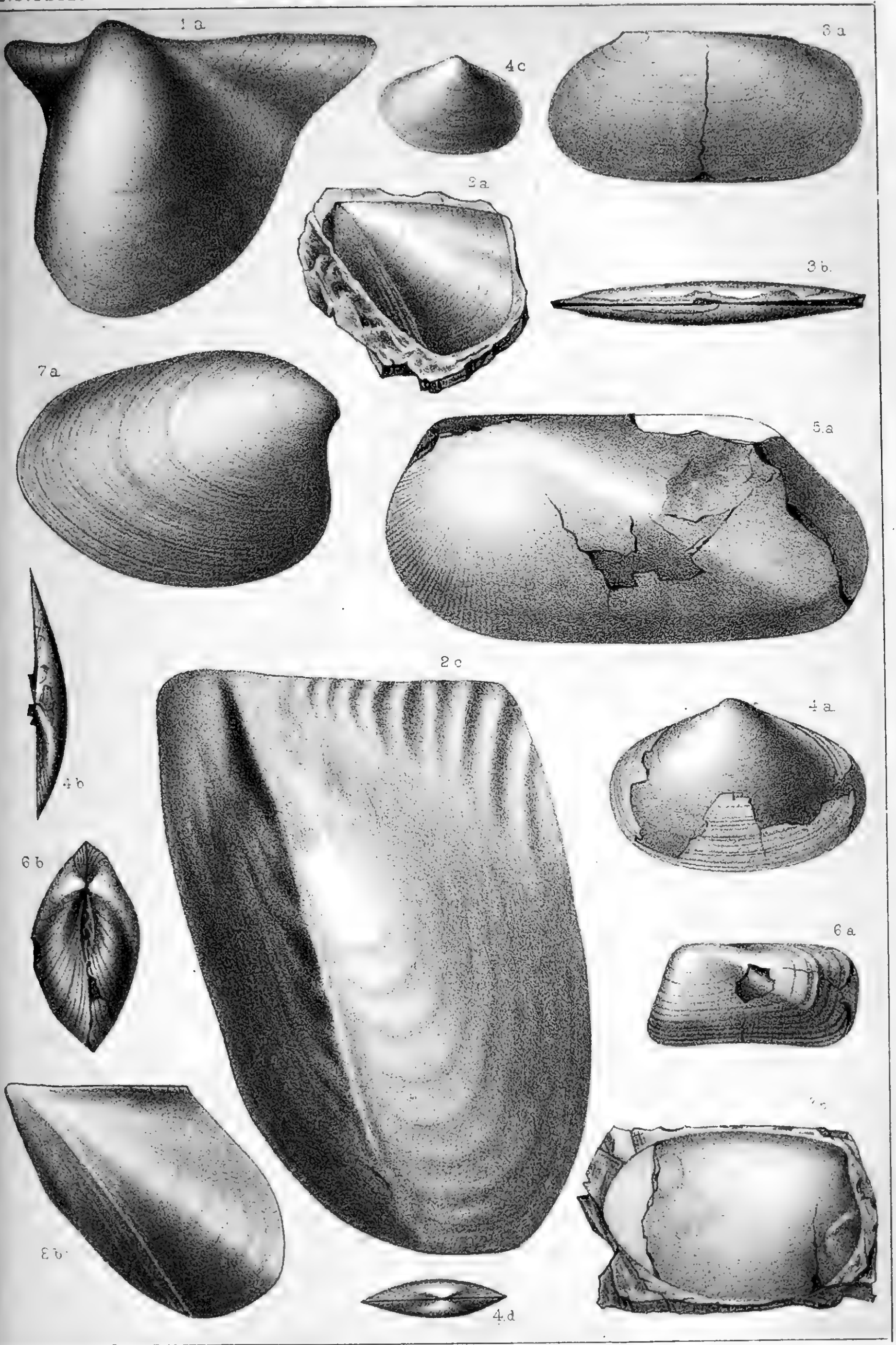
a. Left side view; natural size.

FIG. 6. TRAPEZIUM TRUNCATUM 292

a. Left side view; natural size.
b. Dorsal view of the same specimen.

FIG. 7. CYRENA INFLEXA 290

a. Lateral view; right valve; natural size.
b. Natural cast of right valve, showing muscular impressions and pallial line and sinus.



F. D. Owen Del. Thos. Sinclair & Son, Lith.

REPORT OF ORESTES ST. JOHN, GEOLOGIST OF THE TÉTON DIVISION.

LETTER OF TRANSMITTAL.

OFFICE UNITED STATES GEOLOGICAL AND
GEOGRAPHICAL SURVEY OF THE TERRITORIES,
Washington, D. C., June, 1878.

SIR: I have the honor herewith to submit my report on the geology of the country visited by the northern or Téton division of the United States Geological and Geographical Survey of the Territories during the field-season of 1877.

The party, on the completion of its organization at Cheyenne, proceeded by rail to Ogden, Utah, whence a march of 160 miles to the northward brought us to the southwest corner of the district assigned for the season's operations. The route from Ogden followed the main wagon-road to Montana, skirting the western base of the Wsaatch Range to Malade City, thence crossing over into Marsh Valley and down the Portneuf to where it opens out into the Snake River Basin in the vicinity of Ross Fork Agency, where active work was begun in the Mount Putnam Group on the 12th June.

This part of the journey passed through a section which has already been examined and reported upon by yourself and other members of the survey; besides it lies in the district to which Dr. Peale was assigned as geologist during the past season, to whose report such desultory observations as I was able to make in the course of a rapid march will add nothing.

The region occupied by this division embraces much of the ground explored by the Snake River Expedition under the direction of Mr. James Stevenson in 1872, to which Prof. Frank H. Bradley was attached as geologist, and to whose elaborate report on the geology of the region traversed by that expedition, within the limits of the present district, my own observations are merely supplementary. In many instances Professor Bradley has reported on localities which, for lack of time, it would have been inconvenient to revisit, and in such instances, as also where our routes were the same, on which he has fully reported, I have, for the sake of brevity, subordinated the results of my own examinations to his, only noting such facts as may add to the completeness of previous examinations, with such reference to these latter as is necessary for the unity of the present report.

The district is so situated that its various sections are somewhat isolated, in some cases necessitating long détours in order to pass from one section to another, in which much valuable time was consumed, though not always without some compensating profit to the observer. Partly from this fact, I have been led to divide the district into several sub-districts or sections, which, indeed, possess some natural value on account of their topographic features and hydrographic boundaries, and which are separately treated of in the subjoined report.

Such sections and other illustrations have been executed to accompany the report as are deemed of use in the clearer exposition of the facts in relation to the geology therein cited. And in such cases where I have had occasion to incorporate with my own the observations of others, in order to give to these accumulated results an approach to a connected completeness, due credit has in all instances been given in the proper place.

To the gentlemen of the survey, and especially to my colleagues of the geological corps, I am under obligations for many courtesies and cordial co-operation in the work of the office. In this connection I wish to express my appreciation of the many personal acts of kindness which I shared with members of our little party in the field.

I am, sir, very respectfully, your obedient servant,

ORESTES ST. JOHN.

Dr. F. V. HAYDEN,
United States Geologist in Charge.

REPORT OF THE GEOLOGICAL FIELD-WORK OF THE TETON DIVISION.

BY ORESTES ST. JOHN.

CHAPTER I.

AREA AND BOUNDARIES.

The district of the Téton or northern division of the United States Geological and Geographical Survey is bounded as follows: Commencing at the southwestern corner on the eastern margin of the Snake Plains, in the vicinity of Mount Putnam, on the parallel 43° north latitude, the western boundary of the district follows the meridian 112° 15′ west longitude north to the intersection of the parallel 44° 15′; thence the northern boundary extends east to the meridian 109°; thence south to the parallel 43°, which latter forms the southern boundary of the district. Of this area, which forms a rectangle of one and a quarter degrees of latitude and two and three-fourths degrees of longitude, about 6,000 square miles were actually worked topographically from stations commanding extensive stretches of plateau and plain. A broken region in the southeastern quarter shading off into the upper portion of Green River Basin along its southern border, and embracing a part of the Gros Ventre Mountains, and a considerable portion of the Snake River Range in the region of the Grand Cañon, with a strip on the eastern border including the northern half of the Wind River Range, was, for lack of time and interruption, left unworked.

One of the earliest accounts of the region embraced within the above-mentioned limits is found in the published journal of the missionary Rev. Samuel Parker,* who, in the summer of 1835, performed an arduous journey across the continent to the Columbia. The missionary, as nearly as can be made out, probably entered the country comprised in the present account either through Hoback's Cañon or some pass to the northeast in the Gros Ventre Range, passing into Jackson's Hole, and thence crossing the Téton Pass at the southern end of the range of the same name, into Pierre's Basin. This route probably closely corresponds to that pursued by the early fur-traders, of which Irving has preserved accounts in his "Astoria" of the passage of Mr. Wilson G. Hunt, in 1811, and of Robert Stewart the following year, on their return across the mountains from the Columbia. Mr. Parker's geological notes are in the main easily identified in the localities in this region.

The War Department expedition, under command of Capt. W. F. Raynolds, visited this country in the summer of 1860, and to the report of Dr. F. V. Hayden, published in 1869, who was commissioned geologist of the expedition, we owe the first authentic account of the geological structure of a large extent of country surrounding the sources of the Missouri and the Columbia Rivers. This expedition passed up the Wind River Valley, crossing the range of the same name over Union or Warm Water Pass, and thence descended the Gros Ventre to Jackson's Hole.

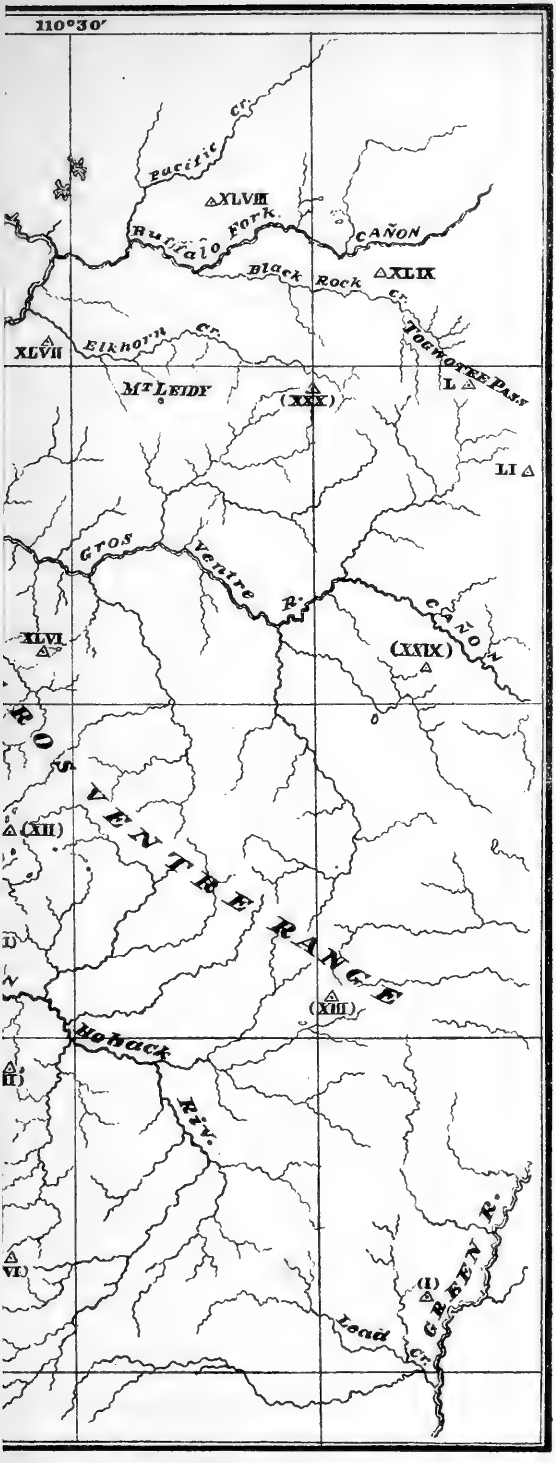
*Journal of an exploring tour beyond the Rocky Mountains, 4th ed., Ithaca, N. Y., 1844.

From the latter point the expedition crossed the Téton Pass, following the western base of the Téton Range into the country north of this district. Notwithstanding the haste with which the expedition prosecuted its march, the salient geological features were seized upon, and wherever later exploration has touched Captain Raynolds's trail, the work has been rather an amplification according to the better opportunity for more extended examinations. The expeditions of this survey have also explored considerable portions of the district; that of 1871 passing along the western border, and the Snake River expedition in the season of 1872 traversed still more extensive portions in the central part of the district in the region of the Téton Range. It is to the latter expedition to which Prof. Frank H. Bradley was attached as geologist, that we owe much concise information relating to the geological history of a large area of territory on the headwaters of the Snake or Lewis River, an interesting account of which is embodied in the Report of the United States Geological Survey, 1872. In the following season Capt. W. A. Jones, of the Engineer Corps U. S. A., in command of an expedition to which was attached Prof. Theodore B. Comstock, traversed the extreme northeast corner of the district. Professor Comstock's report is accompanied by a map on which is indicated the occurrence and distribution of the geological formations over the eastern section of the district lying between the Upper Snake and Wind Rivers. Other expeditions have visited the region for geographical and other purposes at dates remote and late.

With the exception of the southwestern section, we had already much information in regard to the geological and geographical character of the district; mainly, indeed almost wholly, derived from the explorations conducted under the auspices of this survey. Yet the facilities for observation during the past season have enabled the accumulating of a considerable mass of details in further exposition of the regions already partially studied, while in the southwest a tract of virgin ground was explored by this division of the survey during the past season.

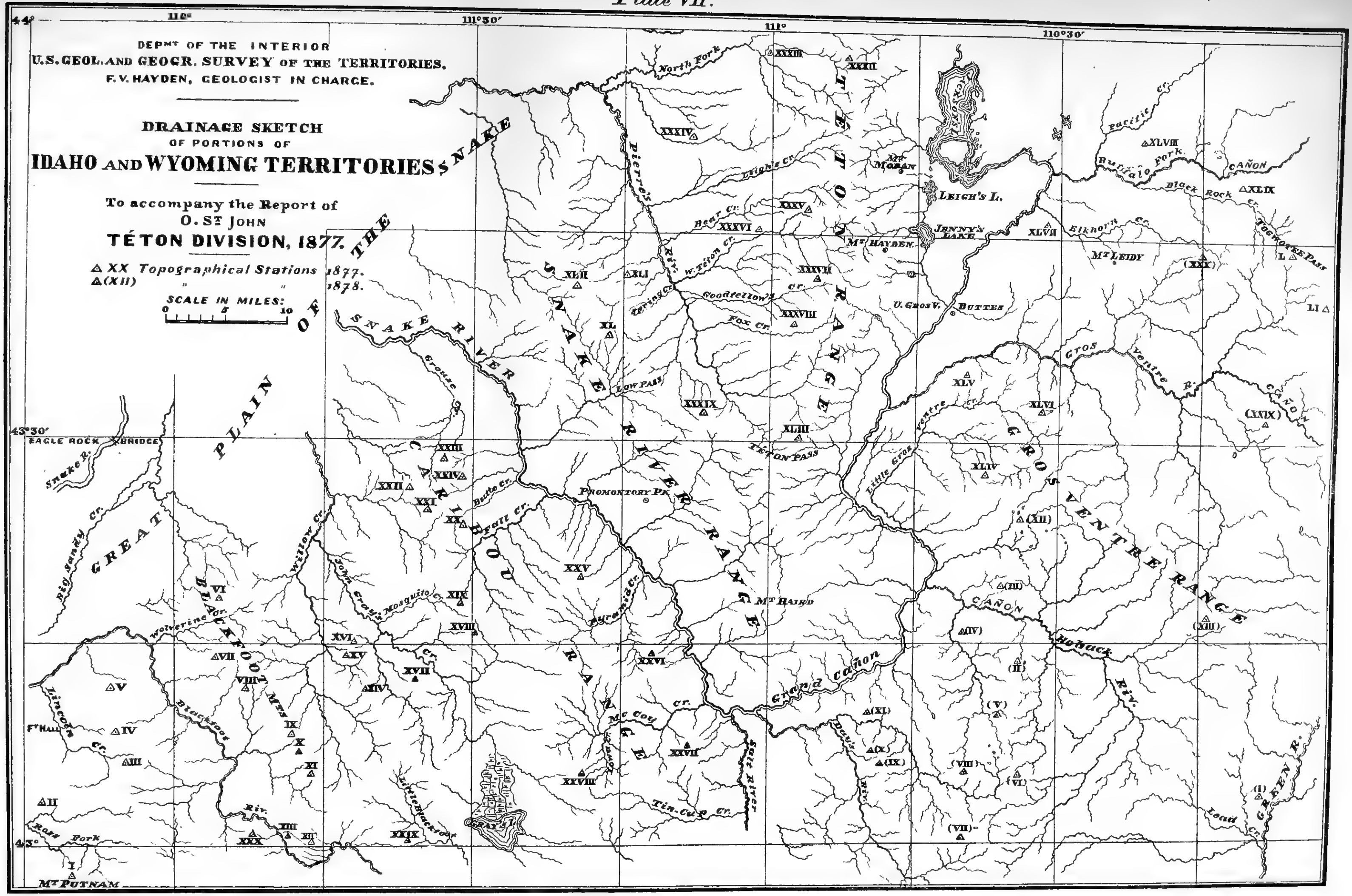
GENERAL SURFACE FEATURES.

Drainage.—The district lies almost wholly within the system of the Snake River drainage, the sources of Wind River rising in the continental water-shed near the northeastern corner. The main Snake River traverses the district in an irregular Z-shaped course, rising in the volcanic area in the northern portion, making its exit near the southwestern corner of the district. It thus makes two great bends within this territory, the first in its passage across the Snake River Range south of the Tétons, whence it flows northwesterly to the northern boundary, where it is again suddenly deflected in a south and southwesterly course to the point where it leaves the district. Nearly half of its course passes through the great volcanic-floored plain of the Snake Basin, the upper half lying within the mountainous area, traversing in graceful windings beautiful mountain basins, its current interrupted by serious rapids only at two points, the one in its wild passage of the gorge through the Snake River Range, and the dalles at Taylor's Bridge or Eagle Rock, below the lower great bend. Its principal tributary is the Henry's Fork, which rises in the water-shed far to the north, beyond our present limits, and joins the main stream in the northwestern portion of the district through a curious delta system in the midst of extensive flats, which are occupied by beaver-ponds and thickly grown with willow. Pierre's River, which lies wholly within the district, draining its northern section west of the Téton Range, also forms a delta in the beaver-ponded flats on joining Henry's Fork a short distance above the confluence of the latter stream with the



110°30′
Pacific Cr.
△XLVIII
Buffalo Fork
CAÑON
Black Rock Cr.
△XLIX
TOGWOTEE PASS
XLVII
Elkhorn Cr.
MT LEIDY
(XXX)
L
LI
Gros Ventre R.
CAÑON
XLVI
(XXIX)
GROS VENTRE RANGE
(XII)
(XIII)
Hoback Riv.
GREEN R.
(I)
Lead Cr.

Plate VII.


DEPᴺᵀ OF THE INTERIOR
U.S. GEOL. AND GEOGR. SURVEY OF THE TERRITORIES.
F. V. HAYDEN, GEOLOGIST IN CHARGE.
DRAINAGE SKETCH
OF PORTIONS OF
IDAHO AND WYOMING TERRITORIES
To accompany the Report of
O. Sᵀ JOHN
TÉTON DIVISION, 1877.
△ XX Topographical Stations 1877.
△(XII) " " 1878.
SCALE IN MILES:
0 5 10
44°
43°30′
43°
112°
111°30′
111°
110°30′
SNAKE
GREAT PLAIN OF THE SNAKE
SNAKE RIVER
SNAKE RIVER RANGE
TETON RANGE
GROS VENTRE RANGE
CARIBOU RANGE
BLACKFOOT MTS
North Fork
Pierre's Riv.
Leigh's Cr.
Bear Cr.
W. Teton Cr.
Teton Cr.
Goodfellow's Cr.
Fox Cr.
Mᵀ MORAN
LEIGH'S L.
JENNY'S LAKE
Mᵀ HAYDEN
Mᵀ LEIDY
U. GROS V. BUTTES
Pacific Cr.
Buffalo Fork
CAÑON
Black Rock Cr.
Elkhorn Cr.
TOGWOTEE PASS
Gros Ventre R.
CAÑON
Little Gros Ventre Cr.
LOW PASS
TETON PASS
PROMONTORY PT.
Mᵀ BAIRD
Pyramid Cr.
Grand Cañon
Hoback Riv.
Green R.
Lead Cr.
Devil's Riv.
Salt River
Tin-Cup Cr.
McCoy Cr.
Grouse Cr.
Butte Cr.
Fall Cr.
Willow Cr.
John Gray's Mosquito Cr.
Wolverine Cr.
Blackfoot Riv.
Little Blackfoot
GRAY'S L.
Lincoln Cr.
Fᵀ HALL
Ross Fork
Mᵀ PUTNAM
EAGLE ROCK BRIDGE
Snake R.
Big Sandy Cr.

Snake. In the southwest, the Blackfoot drains a considerable area in its winding course, finally breaking through the low hill-ranges bordering the Snake plain to the northeast of Fort Hall, and gains the Snake near the southwest corner of the district. The Salt and John Day's Rivers, two fine affluents which rise in the district to the south, reach the Snake at a point just below its debouchure from the Grand Cañon on the southern central border. To the east of the Téton Range the Gros Ventre and Buffalo Fork gather the main drainage on the west flank of the water-shed, joining the Snake in the mountain basin of Jackson's Hole. The ultimate sources of the main stream rise in the divide north of Buffalo Fork, while Lake Fork drains a part of the lake plateau to the north of our district.

Mountain ranges.—In some measure conforming to the drainage system of the region, the mountain belts may be distributed into well-defined areas of greater or less regularity of courses and magnitude. Nearly centrally located, and forming the dominating range whose axial peaks rise 11,000 to near 14,000 feet altitude, the Téton Mountains constitute one of the most conspicuous orographic groups in this northern region. Its orographic relations may be likened to that of a wedge, separating the Gros Ventre on the one hand from the Snake River Range on the other, its longer axis lying nearly meridional a distance of about 40 miles from north to south, and an average breadth of 15 miles.

Along the eastern border, the water-shed north of Warm-Water Pass forms a high wooded divide, which, in the region of Buffalo Fork Peak, is broken down in the gap of Togwotee Pass, from which point it pursues a course east of north, heading Buffalo Fork, and throughout its extent within the district it is made up of a vast accumulation of volcanic materials, which, to the north, rise above timber-line. Intermediate, or between the continental divide and Jackson's Basin, the northeastern quarter of the district is occupied by clusters of sedimentary and volcanic hills and ridges, which the drainage has fashioned into distinct groups, to which belong the highlands between the Buffalo Fork and the sources of the main Snake, and the Mount Leidy groups situated between the former stream and the Gros Ventre River, the culminating points of which attain altitudes of from 10,000 to 11,000 feet above the sea.

To the south of the latter group, the Gros Ventre Range constitutes a rather wide belt of upheaval, trending nearly at right angles to the Téton Range, forming a sort of bridge, or great transverse highland, connecting the latter with the Wind River Range, in the southeastern quarter of the district. The geological relations of this highland belt will be briefly discussed farther on. Its axial course lies a little south of east and north of west, its heights rising 12,000 feet above the sea, and offering great diversity in its geological and concomitant topographical features.

The Snake River Range forms a rather wide and broken belt which rises in the plateau dividing the Green and Bear River Basins to the south of this district, and, pursuing a northwesterly direction, terminates in the Snake Plain south of Pierre's River, after a course of about 60 miles within the present district. It intersects the southern terminus of the Téton Range at an angle of about 45°, to the south of which it is completely severed by the grand cañon of the Snake River. Its eastern limits south of Hoback's River have not been explored, but below the Téton Pass it descends into the lower portion of Jackson's Basin, while to the northwest it is separated from the Téton Range by Pierre's Basin. Its southwestern flank is bounded by the lower valley courses of Salt and Snake Rivers.

In the southwestern section, situate in the great northern or lower bend of the Snake, occur a series of low hill-ranges which in the main extend into the country to the south, with perhaps a single principal ridge, the Blackfoot Range, which occupies a topographically isolated position in the southwestern half of this area. On the east and facing the Snake River Range, occurs a widish belt of hills, the Caribou Range, which falls away into the basin of Willow Creek, which intervenes between its southwestern foot and the Blackfoot Range. This basin area is ridged with low parallel elevations, having the same general northwest and southeast direction. In the extreme southwest the Portheuf Range terminates in Mount Putnam and a belt of low highlands in the angle of the Blackfoot River.

Valleys and plains.—Encompassing the western and northwestern borders of the highland region above briefly outlined, the great plain of the Snake River stretches miles away to the foot of the distant mountain barriers which define the western and northern boundary of this arid waste. Within our present limits this region is scarcely broken by a single elevation, the Crater Buttes at the apex of the northern bend of the Snake, and the Sand-Hills a few miles to the north of the latter, being the only exceptions. But, approaching the highlands, the plain rises in gentle grassy acclivities, whose surfaces are scored by narrow cañons hemmed in by precipitous walls of dark basaltic lava, which in places rise to the height of several hundred feet above the stream-beds. Through such portals the majority of the streams pass on their way from the highlands to the plain.

The highlands are intersected by broad, bay-like recesses, which open out to the north into the plains country, of which, indeed, they form a part physically and geologically. Such are the basins situated between the Caribou and Blackfoot Ranges and Pierre's Basin, between the Snake River and Téton Ranges, extensive level, grassy tracts, which are partially hemmed in by mountain ranges. Jackson's Basin, at the eastern foot of the Téton Range, is an interesting example of mountain-locked valley, which comprises an area of four or five hundred square miles, environed on the east by the comparatively gentle wooded slopes which form the outlying flanks of the mountain borders, and on the west by the Téton Range, whose precipitous walls and massive towers rise 5,000 to 7,000 feet above its surface. The Snake River winds its course through low, willow-fringed flats, between beautiful gravel terraces, and over pebble- and bowlder-strewn bed, receiving on the west bank the numerous snow-fed torrents which debouch into pretty laklets at the foot of the great range, and on the east the larger affluents of ice-cold water which descend from the continental divide.

Subdistricts, or sections.—As above outlined, the district may be divided into mountain and plain regions, the superficial areas of which are respectively as three to four, or thereabouts. Further considered in reference to the topographical and geological characteristics of the district, it may be divided into the following sections, which will be separately noticed in the following chapters devoted to detail geology: The southwestern section, embracing the area reaching up into the great northern bend of the Snake River; the Téton, or middle section, including that portion of the district embraced in the great southern bend of the Snake; and, lastly, the eastern section, which comprises all the territory to the east, lying between the Téton Range and the main water-shed crest, of which, however, only a narrow strip along the western border in the vicinity of Jackson's Hole fell under actual examination during the past season.

CHAPTER II.

SOUTHWESTERN SECTION.

GENERAL TOPOGRAPHICAL FEATURES, DRAINAGE, ETC.

The southern boundary of the district, conforming to the parallel 43° north latitude, forms the base of an irregularly triangular-shaped area, the remaining two sides of which are defined by the Snake River, and comprising in the neighborhood of 1,900 square miles, embraces the territory referred to under the above designation. Of this area quite two-thirds are embraced in the highland region which stretches across the southern line from the western boundary of the district to Salt River, its northern border sinking into the Snake plains, which latter comprise the remaining third of the section. The Snake River boundary, of course, constitutes the main drainage, receiving the numerous affluents which drain the interior southern highlands. Of these, the Blackfoot River, whose course is mainly within this Territory, is the largest. It rises in the central southern portion in a broad basin lying to the north of the Bear River drainage, and flowing southerly, it returns; passing thence northerly a distance of about 25 miles it again suddenly bends westward, breaking through the upraised border of the volcanic flows and emerging into the plain, joins the Snake a few miles north of the southwest corner of the district. It is a fine little stream with a total length of 75 miles or so, with a diversified course of interior grassy, sage plain or basin, basaltic cañon, and open sandy plain. In the extreme southwest the sources of Ross Fork flow down from the Mount Putnam Hills, and gathering on the edge of the plain, flow westward beyond our limits into the Snake. In the northerly continuation of the same basin in which the Blackfoot rises, several other small streams gather their waters from springs which issue from the volcanic ledges and neighboring highlands, and flow northward through Willow Creek into the upland plain where their courses are cañoned in basaltic rocks. Still farther to the east the drainage of a considerable area is accumulated in the marshy depression known as John Gray's Lake, which finds an outlet also through Willow Creek into the Snake to the northwestward, its lower course being cañoned in the basalt of the border upland. The eastern border is drained by several smaller streams, among which McCoy and Fall Creeks are the largest, which take their rise in the heart of the Caribou Range in beautiful little mountain basins, forcing their way across the axis of the range through deep, picturesque gorges. In the southeast, Salt River gains the Snake at a point just below the lower entrance of the Grand Cañon. It winds through a broad valley flanked by hills, which, farther to the southward beyond our district, opens out into an extensive basin-like area.

The eastern border of the region is occupied by a wide belt of low mountains, the Caribou Range, which trends northwest and southeast, with an extent of some 40 miles within this district. Separating the Caribou from the Blackfoot Range, on the west intervenes an extensive basin drained by Willow Creek, the average breadth of which is about 12 miles, and which is traversed by several low, rocky ridges, whose

parallelism denotes their intimate relation to the larger mountain corrugations on either hand. This basin area reaches far to the south, into the district visited by Mr. Gannett and Dr. Peale, where it is described as showing essentially the same surface features. To the west of the Blackfoot Range and within the lower or northern bend of Blackfoot River, an area of between 300 and 400 square miles is occupied by low hill-ridges forming the northern prolongation of the Mount Putnam Range and its outlying eastern highlands, which successively die out in the edge of the plain south and north of the debouchure of the Blackfoot. These low hill-ranges are intersected by parallel valleys and little basin expansions, which pleasantly diversify the country and distribute valuable agricultural lands where otherwise the country would be useful only for grazing purposes.

MOUNT PUTNAM—PORTNEUF RANGE.

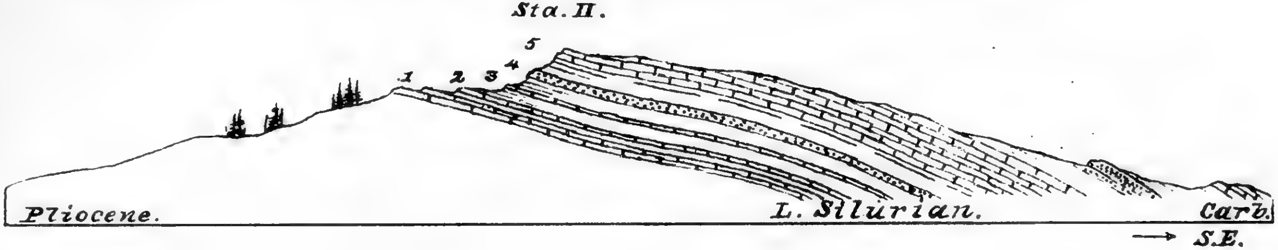
One of the highest points of this range, that on which Station I was made, is situated just over our southern line, in the district surveyed by Messrs. Gannett and Peale, where the range, indeed, attains its principal magnitude. It consists of a somewhat rugged axis of ancient quartzites, alternating with slaty micaceous shales, and apparently resting upon a heavy mass of the latter deposits, which are partially exposed in the high shoulder overlooking Ross Fork drainage, on the west side of the range, facing the Snake plain. Just to the north of Station I, the range is broken though by a branch of Ross Fork, which opens out into a pretty little hill-environed basin, excavated in the sedimentary deposits which succeed the quartzites on the east; and where it crosses the range on its way into the plain it has cut a short gorge across the tilted Silurian quartzites and limestones. This rift marks the northern breaking down of the higher crest of the range, which to the north, within the present district, is continued in a much lower ridge, whose culminating summits rise but a few hundred feet above the Snake plain. This low prolongation of Mount Putnam sweeps round from a north to a north by east direction, terminating in rather abrupt hills, which form the western angle of the debouchure of Lincoln Creek drainage, a few miles south of Fort Hall. The declivity facing the plains is in places quite abrupt, the opposite flank much more gently descending in broad undulations into the shallow depression in which Lincoln Creek and branches of Ross Fork rise, its surface for the most part covered with herbage, with here and there rocky points clothed with gnarled cedars, and copses of undergrowth and aspen clinging to the sides of the ravines which intersect the ridge.

The quartzites which crown the high northern peak of the range pass beyond the western border of the northern ridge prolongation, where they have been denuded and concealed beneath late Tertiary deposits, which, according to Professor Bradley, make up quite an extensive formation outlying the ridge. In the craggy ridge north of the south gorge of Ross Fork the quartzites and limestones of the Lower Silurian reappear, where they show a wavering strike, with a general bearing west of north and dipping east. The strike of the rocks diverges a little west of the trend of the ridge, which, as it bears more and more to the east of north, is successively occupied by more recent deposits, until the Jurassic caps the northeast end of the ridge, as observed by Professor Bradley.

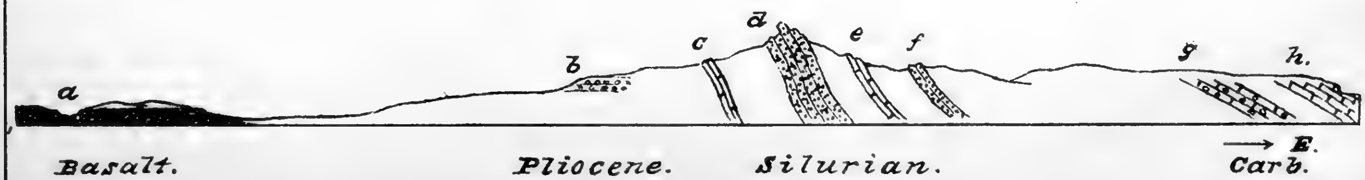
A low spur dividing the Ross Fork drainage from Lincoln Creek, and spreading over a limited area to the north and west, forming an undu-

PLATE VIII.

Section across Mount Putnam ridge, at Station II.



Section along Ross Fork, north of Mt. Putnam.



lating upland which sinks into the plain in those directions, is, according to the same observer, made up of "white and light-gray Pliocene sandstones and limestones, interlaminated with trachytic porphyries and coarse volcanic sandstones, all dipping about north 54° east at angles varying from 15° to 30°." Professor Bradley mentions the existence of an anticlinal at this locality; the same deposits on the opposite flank of the spur are mentioned as showing an inclination of "72°, S. 34° W." In passing up out of the branches of Ross Fork, five to eight miles south of the above-mentioned spur, we soon leave the basaltic flooring of the plain, the way crossing the gentle undulating and gradually rising ascent outlaying the main ridge of the Mount Putnam prolongation, over a light-brown finely-comminuted soil, which is probably largely derived from the degradation of the late Tertiary and their associated volcanic deposits. At the foot of the ridge, north of the entrance of the gorge through which passes a wagon-road from Ross Fork Agency, a limited exposure of loosely-consolidated conglomerate, in thin layers and nearly horizontal, appears in obscure terrace outliers, and which I take to be referable to the above-mentioned Pliocene beds. To the south still apparently similar deposits occur, where they constitute an outlying area corresponding to that between Ross Fork and Lincoln Valley.

Passing up through the Ross Fork gorge at this point along an east-west line, the strata show steep inclination to the eastward, rising up into the monoclinal crest which is here surmounted by a heavy ledge of light-buff quartzite. Beneath, occurs a ledge of drab and buff rough weathered limestone, and several hundred yards to the east of the last a second ledge of dark-gray limestone, steeply inclined with and resting upon the quartzite, forms the east flank of the ridge facing the Ross Fork basin. The latter limestone is apparently in turn overlaid by quartzites, when a space of half a mile or so intervenes in which no rock exposures appear in the low acclivities bordering the stream. Then succeed heavy deposits, showing below dirty-buff weathered conglomeritic limestone, mainly composed of light-gray limestone pebbles with a few of quartzite, and which is overlaid by light-gray and dark-blue cherty limestones, dipping 30° southeast, and reaching a thickness of above 1,000 feet. The upper limestone abounds in characteristic Carboniferous fossils, a large *Zaphrentis* occurring in great numbers, besides *Spirifer*, &c. To the east of the latter exposure, which forms a low rocky point on the north side of the stream, the strata are concealed beneath the superficial materials covering the undulating prairie surface which intervenes between this and the low broad divide next east.

Some three or four miles north of the wagon-road gorge, on a prominent, isolated point of the ridge on which Station II was located, the Lower Silurian limestones rise gently up into the crest, which is more abruptly broken down in the northwest face, in which the exposed edges of a few hundred feet thickness of strata are partly revealed to view. The lower 200 feet or more consists of (1), dark-gray limestone; (2) buff rough weathered limestone; and (3) thin-bedded, dark-gray, brecciated limestone, in which a brief search failed to discover organic remains. Overlying the limestone occurs a ledge of quartzite conglomerate, showing a thickness of 45 feet, but which is evidently only partially exposed. Resting upon the last and forming the crest of the station, a thickness of a few hundred feet of gray, buff-gray, or pink fragmentary limestone, with brecciated layers and shaly partings, occurs, in which the presence of fragmentary remains of trilobites and a small flat gastropod are sufficient to establish the Lower Silurian age of the deposit. This latter limestone near the summit shows a dip of 5° to 15° little south of east,

and sweeping down in that direction so as to cover that side of the elevation.

At the foot of the southeastern spur a heavy bed of light-colored, rough-weathered quartzite appears, dipping 25°, east 30° south; the same deposit again outcropping in the south side of the little gorge which cuts across the ridge just south of Station II. Resting on the latter bed occurs an obscure exposure of rough-weathered buff-gray siliceous limestone, containing a few poorly-preserved fossils, crinoidal columns, and an undetermined brachiopod shell, which may be a *Hemipronites*. The latter rock appears in a low shoulder at the southeast foot of Station II hill, to the east of which the rocks are again hidden beneath the soil.

From Station II the ridge rapidly trends round into the northeast, showing several low rugged summits. In one of these points, a mile or so to the northeast of Station II, obscure outcrops of limestone *débris* were crossed, which are apparently identical with the conglomeritic limestone exposures above mentioned underlying the Zaphrentis limestone ledges which appear in the north bank of Ross Fork. A little farther on to the eastward, indeed, a heavy mass of overlying dark-gray Carboniferous limestone offers the same association and succession of beds as noted at the above-mentioned locality some four or five miles to the south. In an accompanying plate will be found a generalized section exhibiting the stratigraphy and structural features of the monoclinal ridge forming the northern extension of the Putnam ridge within this district.

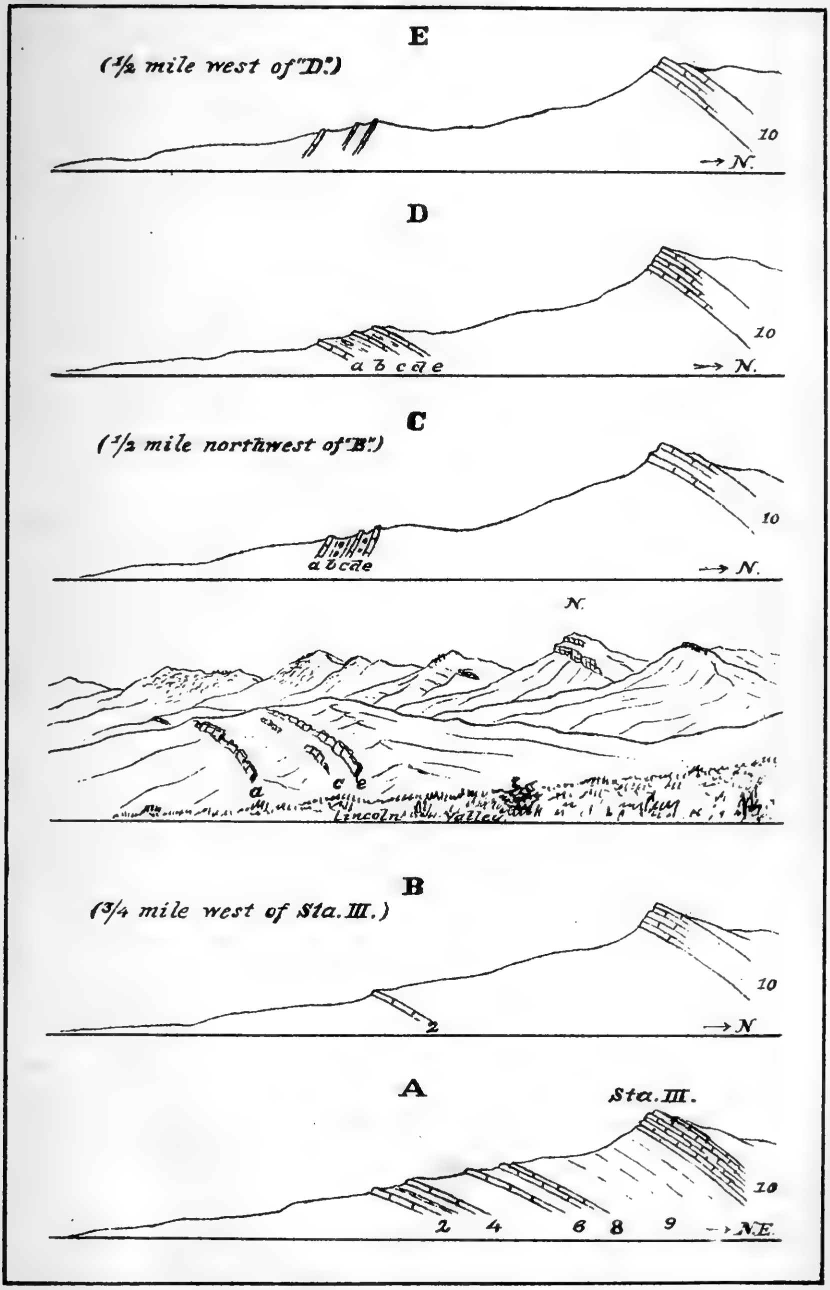
HIGHAM'S PEAK RIDGE, OR ROSS FORK—LINCOLN AND BLACKFOOT DIVIDE.

Extending northward from our south line is a low ridge, which may be designated as the Higham's Peak Ridge, after the peak which constitutes the dominating topographical feature. For the most part this belt forms a broad low divide between the highland course of the Blackfoot on the east and the depression which intervenes between this and the Mount Putnam ridge on the west. The northern portion of this depression is occupied by the Lincoln Valley, while the southern half belongs to the highland basin of Ross Fork. This latter basin and the low divide which separates it from the head of Lincoln Valley or Four-Mile Creek, as it is locally known, embraces an elliptical area of undulating grassy surface in the main mantled with detrital materials, with evidence here and there of the fine brown soil which is common if not peculiar to the disintegration of the Pliocene volcanic deposits. But as to the existence of the latter deposits in this basin, further evidence was not observed.

Lincoln Valley is excavated out of Triassic and Jurassic beds, while that portion of the divide still to the north is flanked by a broad terrace which gently descends to the westward and terminates in low bluff elevations which here define the Snake plain. This border terrace has much the same character as the above-mentioned outlying Pliocene areas, but its mantle of soil completely conceals the nature of the deposits of which it is composed. As in the forks of Ross Fork, the basaltic lava is again met with in the debouchure of a small stream heading in Higham's Peak, and thence northward these deposits increase in frequency of occurrence until they assume the entire area in the vicinity of the debouchure of the Blackfoot River, from whence they curve round to the southward, apparently flanking the eastern slope of this highland belt to a point near the south line of the district.

PLATE IX.

Jurassic ridge N.E. side of Lincoln Valley.



Near our southern border this belt rises into rather prominent ridges which culminate to the south, where they seem to bridge over into Mount Putnam in the water-shed between the Ross Fork and Portneuf drainages. Just to the north, however, the upland exhibits a broad swell over which the Fort Hall and Soda Springs road passes from the head of Lincoln Valley, and which was found to be capped by Jurassic deposits, which occupy a shallow synclinal flanked on the east by Upper Carboniferous strata more steeply inclined westward.

The strike of the strata in this part of the ridge is very variable, yet with some persistency even in its variableness. As we pass obliquely across the divide from a point near our southern line northwesterly to the head of Lincoln Valley, the strike in the Carboniferous border deposits swerves round from N. 30° E. to N. 20° W. as we reach the axis of the Jurassic ledges, beyond which, in the slope descending to Lincoln Valley, the beds again strike about northeast and southwest, dipping at a moderate angle to the southeastward. It is, therefore, evident that this portion of the divide owes intimate connection with the Putnam ridge. But passing only a few miles farther north, in the monoclinal ridge flanking the northeast side of Lincoln Valley there were observed evidences of an abrupt change in the direction of the disturbing forces accompanied by extraordinary local disturbance, resulting in the strata being upraised and folded along a line bearing north of west and south of east, with local variations in the strike and degree of inclinal which it would require much time thoroughly to decipher.

In the southwest slope of this ridge, even within comparatively short distances, of but a few score of yards in some instances, the strata are warped from a northerly to north-northeast inclination of 25° to 50° to a dip in the opposite direction at angles varying from 65° to 80°. It is possible, as has been suggested by Professor Bradley, whose examinations in this quarter were much more extended than my own, that the steep southerly dips here noticed mark the position of the dragged and upturned edges of the strata along a line of faulting the downthrow of which was to the south, though to what vertical extent was not ascertained. For the clearer illustration of the facts referred to, the accompanying sheet of diagrams is introduced, which represents the rock sections observed in the north-side ridge on Lincoln Valley or Four-Mile Creek, from Station III to a point a mile or two to the northwest, two or three miles beyond which the Jurassic spur terminates in the sage-plain bench east of the Lincoln. At the latter point the limestone strata show variable dips, at one place the beds pitching steeply eastward at an angle of 50°, while in a short distance south they incline more gently southward. In the southwest slope of Station III, the following section of Jurassic strata occurs:

Section at Station III.

1. Long grassy slope to Four-Mile Creek, no rock exposures.
2. Gray, heavy-bedded limestone, in two layers, exposed 4 feet; dip N. 25° E°., at an angle of 20° to 25°. This ledge appears at a level of about 600 feet below summit of station, and containes a large *Pseudomonotis* or *Aviculopecten*, a small *Gryphæa* or *Ostrea*, *Camptonectes*, and *Lingula*.
3. Layers of brown, weathered, gray limestone, interbedded with clayey matter, obscurely exposed in slope. The limestones also contain *Pseudomonotis*.

4. Gray limestone, containing numerous small *Gryphæa*. Obscure outcrop at a level of about 130 feet above No. 2.

5. Slope representing a thickness considerably greater than the difference in level between beds No. 4 and 6, probably 100 feet.

6. Similar gray limestone, with *Pseudomonotis*, &c.; dips N. 25° E., at an angle of 26°. Obscure exposure 40 to 60 feet above No. 4.

7. Slope, 50 to 100 feet.

8. Very hard, dark-gray limestone, with small *Gryphæa?*, &c., overlaid by a heavy ledge of lighter pinkish-gray limestone, with same fossils. Strike and dip same as lower ledges. The latter ledges appear in a bench, from which the slope sweeps up into the summit over the following beds.

9. Reddish-tinted shales, obscurely exposed in steep slope covered with limestone *débris*, and representing a heavy deposit, possibly including limestone layers.

10. Buff-gray, thin-bedded, or shaly, slightly gritty limestone, forming a heavy ledge; dip 34°, N. 5° W. The lowest outcrop occurs at a level of about 250 feet above No. 8, and as we ascend the hill the ledges rise, showing similar buff-gray gritty limestones, the strike swerving round more and more north of east, until in the summit the beds dip N. 30° W., at an angle of 35° to 40°. There is here exposed a thickness of above 100 feet of these arenaceous limestones, with shaly partings. Some of the layers contain a small *Pseudomonotis*, *Aviculopecten*, and other fossils prevalent in the lower limestones.

Apparently the same ledges mentioned under bed No. 10 of above section form the crest of the ridge to the west-northwest, which here bounds Lincoln Valley on the north. In the slope descending into the valley from this ridge we meet with the disturbed strata mentioned in a previous page. The first exposure occurs about three-quarters of a mile to the west-northwest of Station III, and is that shown at 2, B, in accompanying plate. It consists of a heavy ledge of gray limestone, exposed 15 feet, dipping 25° to 30°, N. 15° E. It is possibly the equivalent of bed No. 2 of the foregoing section. Half a mile or so northwest of the last exposure, apparently the same ledge appears, associated with several others, shown in diagram C, as follows: *a*, dark-brown ferruginous limestone, 10 feet exposed, and dipping at a less steep angle of inclination than the overlying beds; *b*, shales, with dark ferruginous limestone layers and concretionary masses, occupying a space 100 yards across; *c*, rusty-gray limestone; *d*, shales, with dark ferruginous concretions, space 50 yards across; *e*, gray limestone, dipping 80°, S. 30° W.

A short distance to the west the same ledges again dip north-northeastward at an angle of 35°, as shown in diagram D. And a quarter of a mile or so farther westward the strata again appear in a low ridge, dipping S. 25° W., at an angle of 60° to 65° (diagram E). To the west these deposits are soon lost to view in the *débris* covered slopes, which latter form low bluffs near the stream, in which obscure exposures of reddish, indurated arenaceous shales and soft and reddish sandstone *débris* were noticed, but no outcrops by which their relations to the above-mentioned deposits might be determined, although they have been compared with the "Red Beds" of the Trias. Similar sandstones and chocolate-colored shales, including layers of nodular limestone, occur in the horizon of the Triassic beneath the Jurassic strata in the broad synclinal ridge a few miles to the southward, and in a more considerable elevation beyond our southern line, and about due east of Mount Putnam, as seen from a distance, a set of red-colored beds appear in force, which may also prove to

have intimate relationship with the deposits so obscurely exposed in Lincoln Valley.

The section extending across the synclinal divide, from a point near our southern boundary, northwesterly to the head of Lincoln Valley is shown in an accompanying plate, which gives such stratigraphical details as came under notice in this part of the ridge. The section does not, however, pursue a direct course, but it is carried by a series of offsets northwesterly and at right angles to the strike of the strata, which was made necessary by the form or direction of the divide.

Section across the Ross Fork—Lincoln and Blackfoot divide.

1. Calcareous spring-deposit, evidently quite extensive accumulations in the borders of the little basin.
2. White and buff heavy-bedded sandstone, exposed in bluffs short distance below the Ross Fork road. Dip 25°, W. 20° N.
3. Drab-gray, laminated, fragmentary limestone, lower layers light and gritty, interbedded with buff sandstone. Dip 25°, W. 15° N.
4. Shaly brown-buff, gritty layers and hard sandstone.
5. Gray and dark drab fragmentary limestone. Contains a small coral like *Stenopora*, also obscure Lamellibranchiates, a small *Pleurophorus* and *Schizodus* (?). These fossils possess a Permo-Carboniferous facies, though they may be found to be associated with others of Upper Coal-measure species. This limestone forms a heavy ledge.
6. Limestone like the above, with black chert.
7. Space covered with limestone *débris.*
8. Light-grayish buff and reddish heavy-bedded sandstone. Dip 30°, W. 30° N.
9. Sandstone, obscure exposure.
10. Buff, reddish-brown weathered, very hard sandstone, 8 to 10 feet exposed. Dip 25° to 30°, W. 15° N.
11. Gray, buff-yellow, and brown standstone, interbedded with gray limestone. A heavy deposit.
12. Heavy bed of gray limestone.
13. Heavy deposit of buff sandstone, generally heavy bedded and sometimes granular, with ripple markings and slickenside surfaces. Dip 30° to 50°, W. 25° N., curving up into part of an arch.
14. Obscure ledges of sandstone and possibly limestone.
15. Gray, gritty, fetid limestone, obscure exposure.
16. Brittle, buff sandstone, dips steeply westward.
17. Gray limestone with black chert. Dip 60° westward. Contains casts of fossils, an *Aviculopecten?* and two or three other forms of Lamellibranchiates, *Dentalium?* and one or two small forms of Gasteropods, the whole group bearing Jurassic facies, but specifically indeterminable.
18. Soft, reddish-buff sandstone and limestone *débris.*
19. Buff, rusty, rough-weathered sandstone, obscure exposure.
20. Gray and yellow shaly limestone, fragmentary.
21. Drab and dark-gray shaly limestone and buff siliceous limestone, obscure exposure. Dip 20° to 30°, W. 5° N.
22. Reddish sandstone and limestone layers and *débris.*
23. Gray magnesian? limestone, with black and pink chert. Dip 25°, W.
24. Space, covered with rock *débris.*
25. Gray, chocolate weathered, fragmentary limestone. Dip 47°, W. 25° S. Contains a small *Lingula* and an obscurely preserved small, coarsely concentrically ribbed Lamellibranch, possibly *Trigonia.*

26. Drab shales, with indurated layers.

27. Rusty buff areno-argillaceous indurated layers. Dip 40° to 45°, W. 15° S.

28. Rusty-gray, chocolate-brown weathered, even-bedded limestone. Dip 43°, W. 20° S. Contains *Aviculopecten ?*, a small *Pseudomonotis ?*, *Camptonectes ?*, and a form resembling *Mytilus;* all common forms in Jurassic horizons in this region. There are several layers, at least five, of this limestone alternating with softer deposits, making up a heavy deposit 300 to 500 feet in thickness.

29. Unexposed space, 500 to 800 yards.

30. Light-gray limestone, similar to bed 28, showing several layers, dipping 5° to 20°, E. to E. S. E. The upper layer is charged with a small *Pseudomonotis ?* and *Aviculopecten.* These layers bear a general resemblance in their lithology to those mentioned under No. 28, but their identity was not conclusively determined, although it seems very probable. From this point, descending to the valley of Lincoln Creek, the strata dip very gently easterly, forming the west slope of the synclinal trough, the axis of which approximates that of the divide.

31. Shaly limestone, like the last preceding, two or more layers. Like the preceding limestone layers, the present layers dip gently south of east at an angle of 5° to 10°, but soon increasing to 20°, with indications of local disturbance in masses of strata dipping at a steeper angle north of east.

32. Rusty-gray, chocolate-brown weathered, thin-bedded limestone, recalling the crest-ledges mentioned under No. 28, also No. 25.

33. Reddish-buff, thin-bedded sandstone, and variegated, chocolate-colored, partially indurated shales, interbedded with drab-gray, fragmentary limestone. Its equivalent in the opposite side of the synclinal was not recognized, although it probably holds a position below bed No. 25.

34. Drab-gray, fragmentary limestone, alternating with partially indurated chocolate-variegated shales, imperfectly exposed over a wide space, terminating in ridge overlooking Lyncoln Valley, toward its head.

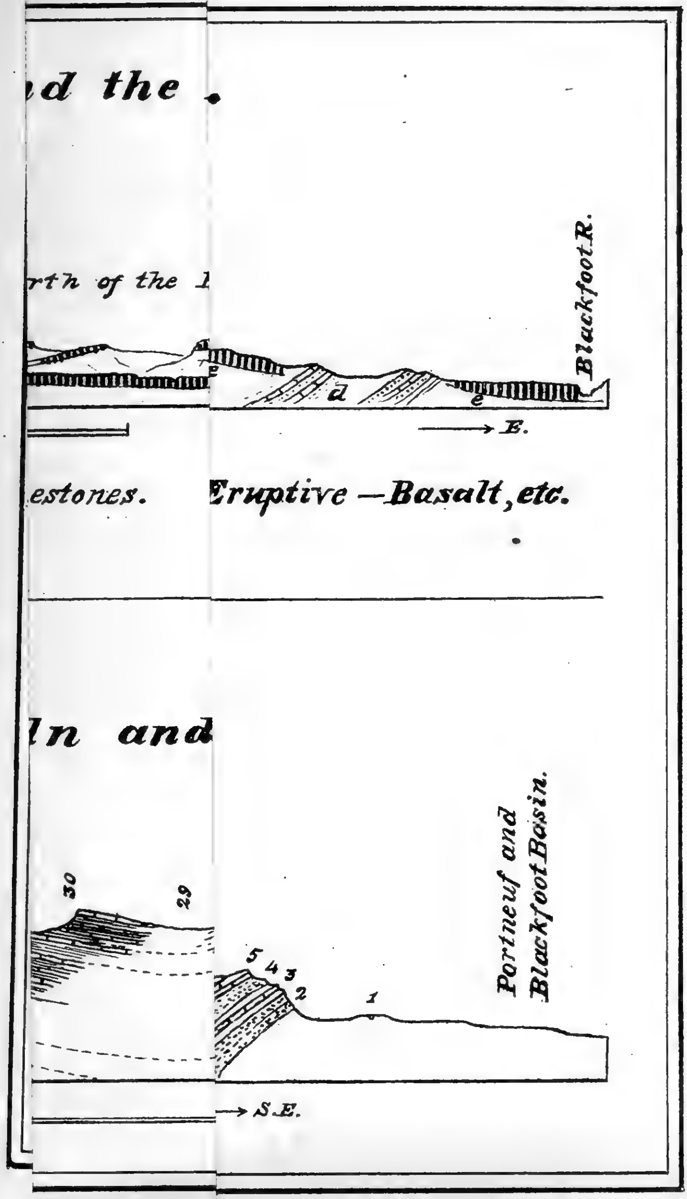
35. Ledges of pink or pale-reddish, heavy-bedded sandstone, extending 150 to 300 feet below summit of above limestone-capped ridge.

36. Heavy-bedded, gray, gritty limestone, 3 feet exposed, dipping gently southeasterly.

37. Grassy slope, showing no exposure of rocks, thence to Lincoln Creek.

At the head of the little stream which joins the Lyncoln at Fort Hall, a distance of 5 miles east of the post, the ridge rises into a prominence on which Station IV was made, 2,200 feet above the plain in the debouchure of Lincoln Valley. The first rock encountered ascending this little stream crowns a low hill on the north side at an elevation of about 500 feet above the post, and one and a quarter miles distant. This consists of reddish, yellow-mottled, coarse sandstone, dipping 20° to the southward; bed *a*. About a mile farther east a heavy deposit of deep red sandstone forms the summit of a higher elevation, the beds dipping 25° to 30°, W. 15° to 25° N.; bed *b*. One-half or three-quarters of a mile east-southeast of the last exposure, in the north bluff of a gorge through which a branch of the stream flows at this point, a heavy ledge of drab-gray limestone appears, in the upper layers of which a few obscure fossils were found; a *Pseudomonotis* and a small *Ostea*-like shell, which indicate the Jurassic age of the beds in which they occur. The limestone shows a variable dip and strike at the several exposures examined, ranging from 20° to 50°, W. 30° to 80° N.; bed *c*. These limestones are ap-

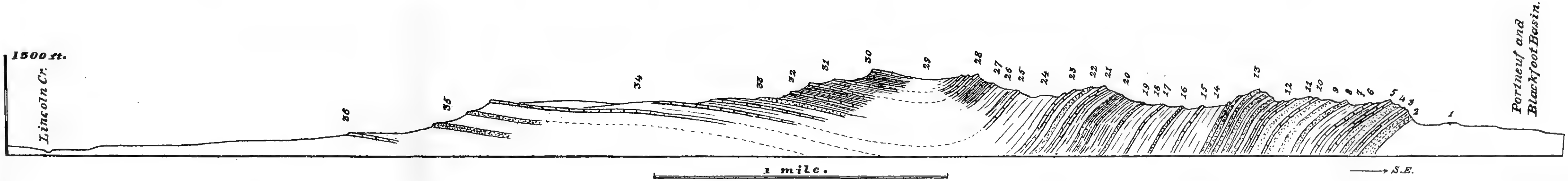
Plate X.


d the
rth of the
Blackfoot R.
d
e
→ E.
estones.
Eruptive —Basalt, etc.
ln and
30
29
5 4 3 2
1
Portneuf and
Blackfoot Basin.
→ S.E.

Profile and Section between the Blackfoot and the Portneuf, through Station XXX.

a. Portneuf-Blackfoot Basin. b. Pliocene conglomerates, etc. c. Pliocene marls and limestones. d. Jurassic limestones and sandstones. e. Eruptive—Basalt, etc.

Section across the Ross Fork-Lincoln and Blackfoot Watershed.



parently underlaid by red sandstones, the *débris* of which was seen in the surface of an adjacent eminence, a few hundred yards northeast. One and a half miles or thereabouts to the southeast of the limestone bluffs, a heavy deposit of red, even-bedded, ripple-marked sandstone makes up the bulk of a large hill a few hundred yards to the northwest of and parallel with the comb of Station IV. These sandstones dip at an angle of 45°, N. 25° E.; bed *d*. The sag intervening between this and Station IV ridge is eroded out of a softer, deep-red arenaceous bed (bed *e*), which, together with the sandstone, bears a marked resemblance to the Triassic, as elsewhere developed in the district.

Station IV occupies the summit of a rough-weathered comb, composed of a heavy bed of coarse, red sandstone alternating with conglomerate, all of which is more or less changed to the condition of a quartzite; bed *f*. This ledge dips 45°, N. 15° E., and it may be traced a distance of a mile or two along an east-west course; the outcrop in the west spur being distinctly visible from Fort Hall, and which forms a higher parallel ridge with the Jurassic-capped ridge north side of Lincoln Creek. In crossing from Station IV to the latter ridge, a mile or so southwest, the upland revealed a single exposure of gray limestone about two-thirds the way across, when we come to the northeasterly-dipping, rusty weathered gritty Jurassic limestone which caps the Lyncoln Valley ridge two to three miles northeast of Station III.

The strata above noticed are observed to swerve round in strike, the sandstones in the border-slopes between Station IV and Fort Hall having a trend almost at right angles to the beds in the station and neighboring ridges, which latter evidently belong to the uplift of Station III ridge; while the soft border sandstones show evidence of much complication, at one place the inclination changing from that above noticed, 20° southward, to N. 25° E., at an angle of 55° to 60°.

Four miles to the northward of Station IV, on the culminating point of a very similar ridge known as Higham's Peak, Station V was located, at an altitude of about 6,600 feet above the sea, or a couple of hundred feet lower than the former station. Approaching this ridge from Fort Hall in a northeasterly direction, the first two miles passes over the gently-rising bench which outlies the foot-hills. The first rock here met with is a heavy bed of drab-gray limestone interlaminated with shales and light-drab laminated limestone with obscure traces of fossils, showing a thickness of perhaps 30 feet, dipping southwestwardly at an angle of 25° to 45°. The rock closely resembles the limestone noticed in the gorge a couple of miles northwest of Station IV, with which it is believed to be identical. One hundred yards northeast of the last exposure a limited outcrop of thin-bedded red sandstone appears, which holds an inferior stratigraphical position, and dips 25°, W. 50° to 65° N. Within a distance of a mile to the northeast of the last a similar red sandstone outcrops in a hill at an elevation of 500 to 600 feet above the limestone exposure, showing an inclination of 37°, W. 25° S.; and in the saddle a few hundred yards northeast a heavy-bedded, coarse, pinkish-white, and reddish sandstone dips beneath the foregoing at an angle of 35°, W. Thence a high, undulating, grassy upland with no rock exposures is crossed, 1½ to 2 miles, when a deep ravine half a mile southwest of Higham's Peak is reached, where the lower strata consist of limestones affording Carboniferous fossils, succeeded by soft buff and chocolate-red variegated sandstones and sandy shales and heavy ledges of grayish-buff and reddish sandstones and conglomerate, including a layer of cherty limestone with crinoidal remains; the whole making up a thickness of several hundred feet of much-disturbed and apparently

overturned strata, which form the crest and higher shoulder of the ridge.

The section here alluded to is given in an accompanying plate, and described below:

Section through Higham's Peak, Station V.

1*a*. Porous, buff, magnesian limestone, 2 feet exposed.

1*b*. Two thick ledges of heavy bedded, drab, brittle limestone, cancellated structure in places, separated by a space of about 40 feet. Dip variable, the lower ledge at one point inclining at an angle of 30°, N. 15° W., the upper one dipping 15° to 20°, N. E.

1*c*. Slope 80 yards across, and representing a heavy bed of shaly material, the limestone *débris* affording a few imperfect Carboniferous fossils, crinoidal columns, *Spirifer*, *Myalina?*, *Aviculopecten*.

1*d*. Several layers of limestone, forming a heavy deposit, at the base drab, followed by buff-mottled thin-bedded layers, with chert nodules; light gray, compact, thin-bedded limestone; dark drab-mottled limestone, minutely cancellated, fragmentary, containing a large Lamellibranch. These beds are very variable in inclination, dipping 40° to 80°, N. 25° E. to N. 5° W.

2. A wide space, showing obscure exposures of generally soft, buff sandstone, probably included in shaly deposits, with harder, thin-bedded, chocolate-red variegated sandstone layers; on the south occurs thin, indurated buff arenaceous layers, mingled with red sandy indurated shales, with small sand nodules, interbedded with buff firmer sandstone.

3. Dark red sandstone, forming low comb, 220 yards south of bed 4, and 300 yards north of No. 1*d;* dip and strike variable, 70°, N. 45° E., and 80°, S. 50° W.

4. Coarse, sometimes conglomeritic, heavy bedded, light and reddish, laminated and cross-bedded sandstone, forms a rugged comb parallel with but lower than Station V ridge 400 yards north. Dip in crest, 60° to 70°, S. 50° W., and on the south side 80° to 85°, S. 10° E.

5. Drab cherty limestone, below almost pure chert, with small crinoidal columns, forming a ledge exposure 50 yards across. Dip 62°, S. 45° W.

6. Deep red arenaceous shales, interlaminated with hard red and light creamy mottled sandstone layers, exposed in saddle 70 yards across.

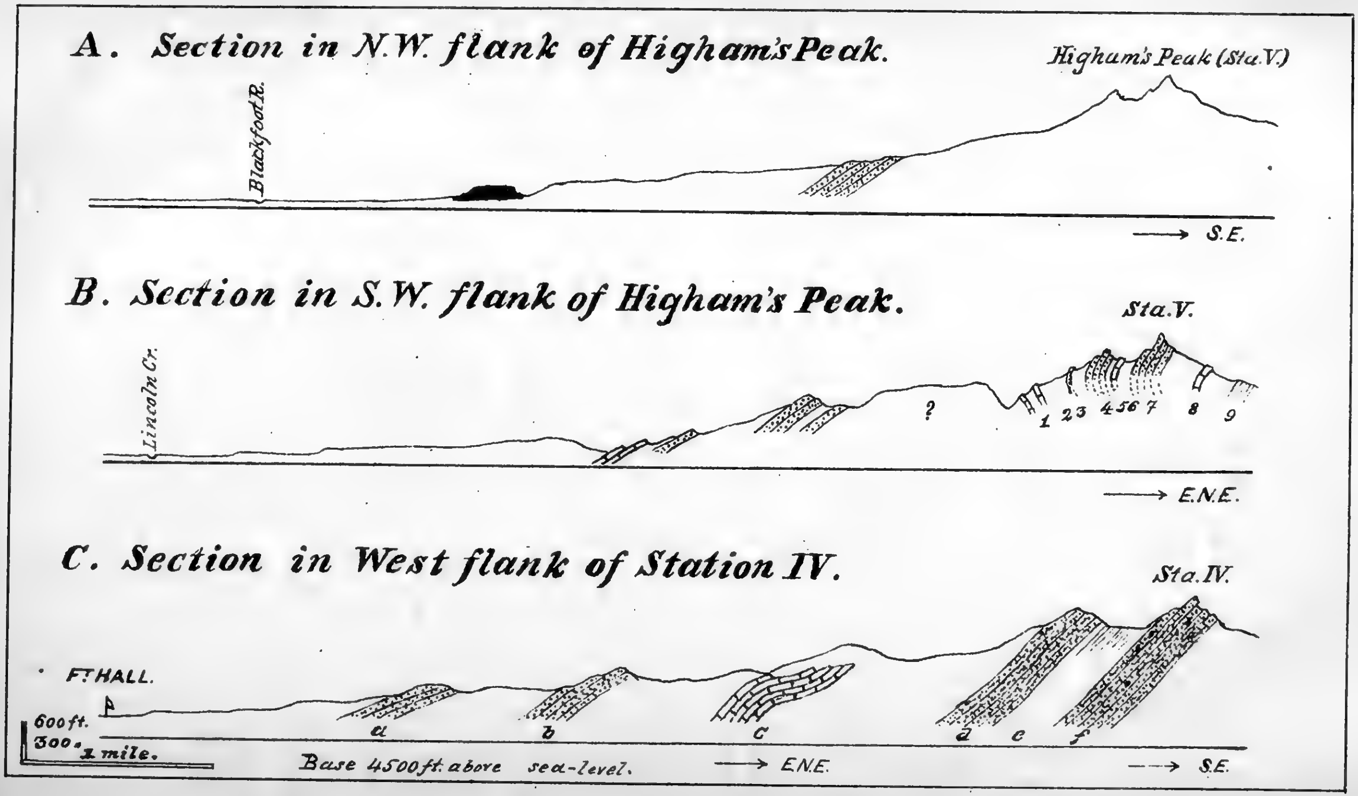
7. Hard, thin-bedded, buff and reddish, laminated, rarely ripple-marked, sandstone, forming a heavy deposit in summit at Station V, 300 yards across the exposure. Dip 30° to 85°, W. 20° to 40° S.

8. Heavy bedded, drab, brittle limestone, dipping southwesterly at a more moderate angle of inclination. Exposed in northerly slopes 300 feet or more below summit.

9. Drab indurated calcareous deposit, dips southwesterly at a steeper angle, but showing obscure exposures.

It will be observed that the strata at this locality exhibit considerable variability in the direction and rate of strike and inclination, with, however, marked conformity to the ridges on the southwest, showing that their upheaval was due to the same set of dynamical actions which folded the Mesozoic strata in the ridges of Stations III and IV. The limestones No. 1, from their fossil contents, are probably referable to late depositions of the Carboniferous period. But owing to the insufficiency of our data, in consequence of the isolated position of the ridge, it becomes a matter of conjecture in attempting the correlation of these beds with deposits elsewhere observed in this region and their connection with undoubted Mesozoic deposits which outcrop at a distance and

PLATE XI.


A. Section in N.W. flank of Higham's Peak.
Higham's Peak (Sta.V.)
Blackfoot R.
→ S.E.
B. Section in S.W. flank of Higham's Peak.
Sta.V.
Lincoln Cr.
?
1 2 3 4 5 6 7 8 9
→ E.N.E.
C. Section in West flank of Station IV.
Sta.IV.
Ft. HALL.
600 ft.
300 "
1 mile.
a
b
c
d
e
f
Base 4500 ft. above sea-level.
→ E.N.E.
→ S.E.

lower level on the western slope of the highlands, to bring the whole into intelligible relationship. Hence I have preferred to give a rather full statement of the facts observed, which, in connection with the section diagram, will, I trust, be readily understood.

Between two and three miles northwest of Higham's Peak, in the low bluff-borders of the little stream which descends from this point into the plain, an exposure reaching several hundred feet in thickness, consisting of buff and reddish, thin-bedded sandstone was observed, dipping 35°, N. 20° W. Half a mile lower down the stream, a less extensive outcrop of reddish sandstone shows an inclination N. 35° E., at an angle of 60°. These deposits are probably identical with the sandstones north of the Coldwater, a couple of miles east of Fort Hall, mentioned on a preceding page. They are here seen to form a low ridge of hills, which in a short distance to the northward sinks beneath the high volcanic benches which fill the debouchure of the Blackfoot and which occupy a wide belt along the eastern margin of the highlands descending to the Blackfoot. Wherever these sandstones are exposed in this western border belt on the margin of the plain they show unmistakable signs of confused disturbance, which in certain localities seem to amount to non-conformity with the Jurassic limestones in their immediate neighborhood. But not the slightest evidence of an organic nature was detected by which their age might be fixed, while, as above intimated, the other evidence is so confused as to afford little light in so important a determination.

To the southeast a group of low hills and upland basins intervene between the Blackfoot and the southern portion of the highland divide above described, which on the east show tilted Jurassic limestones and sandy beds, inclining southwesterly, and which belong to the southwestern flank of the system of folds just across the Blackfoot in the vicinity of Stations XII and XIII, hereafter to be described, and which are evidently intimately related to the disturbed belt between Stations III and V. There are two principal upland swells, separated by shallow basins which drain north into the Blackfoot, the western basin also draining south into the Portneuf. The eastern basin is floored by basalt, while the western one shows stretches of marshy, bitter flats, bordered by low benches, with extensive spring deposits of calcareous tufa which in places form quite extended benches in the borders at the foot of the steeper acclivities. The springs which built up the latter deposits have become almost extinct, though a few feebly-flowing ones are still to be seen.

The eastern ridge is based on the Jurassic, which to the southward probably rises up into more prominent ridges. But in this quarter the bulk of its mass consists of the light marls and white limestones of the Pliocene, which dip 20° to 25°, N. 30° E., the summits of the ridges, as at Station XXX, being formed of cappings of trachyte and basaltic lavas, dipping in the direction of the Blackfoot, or northeasterly at an angle of 15° to 20°. Hence the tilting of these late Tertiary beds must be attributed to forces acting elsewhere than in the belt of Jurassic folds just over the Blackfoot in Station XIII. The light cream-colored limestones are perforated with the numerous molds of fresh-water gastropoda, a species of *Melania?* being especially abundant and often the only fossil found in these beds. Both in their lithology and organic remains, these beds are unmistakably like deposits observed by Dr. Hayden, in 1871, in the region of Great Salt Lake Basin to the south, and which are also mentioned by Professor Bradley, who visited the same districts during the following season, where they are referred to late Tertiary or Pliocene age.

The broader upland ridge next west is covered with a fine soil, with some water-worn *débris* of red sandstone, quartzite, and gray limestone. On the western border, in the ravines which cut the abrupt slope on this side, heavy ledges of conglomerate are met with, dipping 10° to 20° in a northeasterly to southeasterly direction, and reaching a thickness of at least 300 feet, probably much more. These deposits are quite variable in their lithological aspect, sometimes appearing as coarse sandstones easily crumbling, again showing a conglomerate structure made up of water-worn pebbles and small bowlders of quartzite, limestone, trachyte, and basalt, arranged in more or less distinct layers and cemented with a fine light-drab paste. The deposit is probably identical with similar accumulations occurring elsewhere in this region, which have been provisionally referred to volcanic origin. To the north the ridge rises into a high point, which is capped by westerly-inclined volcanic ledges, and which once formed a continuous sheet with the wide belt of flows filling the Blackfoot Valley.

BLACKFOOT RANGE.

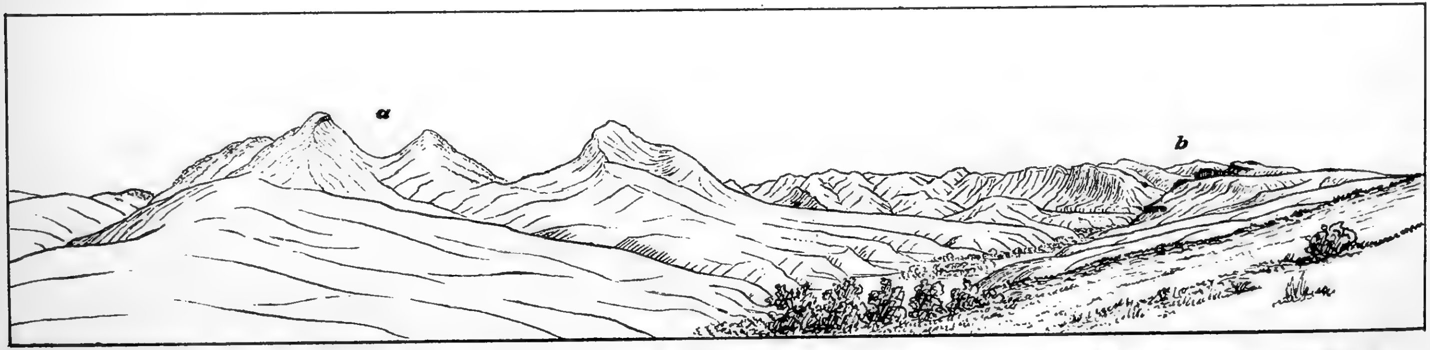
Parallel with, and lying a few miles to the northeast of, the cañoned course of Blackfoot River, the country rises into a low range of mountains, which forms the divide between the latter stream and a wide basin which drains northward through Willow Creek into the Snake Plain. This range, known as the Blackfoot Mountains, has a north-northwest and south-southeast extent of some 20 to 25 miles, and with the lower parallel ridges on the west a breadth of 4 to 7 miles. To the south the main ridge gradually sinks into a low plateau and level basin expanse, through which lies the upper course of Blackfoot River and the sources of Willow Creek, while to the north it divides, sending off a low rocky spur, across which Wolverine Creek has cut a picturesque cañon, the eastern and more rugged branch culminating in Blackfoot Peak, a high dominating point near the northern end of the range, which attains an altitude of 7,400 feet, or about 2,600 feet above the Snake Plain. The southwestern face of the range presents a comparatively bare, rocky escarpment, the opposite slope falling away in successively lower branches, and is more or less densely clothed with pine and spruce forests and thickets of undergrowth.

Our route of approach followed the Blackfoot, which, just before it emerges into the plain at the northern bend, has cut a deep narrow gorge through the volcanic rocks which incline at a moderate angle in the direction of the plains, and which form the coping of a line of bluffs along the west side of the Blackfoot above the cañon, south. In the lower walls of this cañon, Dr. Hayden, who visited the locality in 1871, found heavy ledges of rusty weathered quartzite, overlaid by Carboniferous limestone, all dipping steeply to the northeast. In the north side of this cañon the way passes high up over the basaltic ledges, which bury the sedimentaries beneath an accumulation of several hundred feet thickness of volcanics.

Wolverine Creek joins the Blackfoot at this point from the east, its lower course lying in a narrow valley with sloping *débris* benches on either hand, on the north covered with cedars and merging into the volcanic foreland, which sweeps down to the level of the plain in that direction, the south side acclivities rising in smooth, grassy curves up into isolated trachytic domes which mark the remnant of a once extensive flow dating back to the earlier period of volcanic activity.

The first limestone ridge, or the western spur of the Blackfort Range,

PLATE XII.



Confluence of the Blackfoot and Wolverine. (Looking S.W.)

a. Trachyte-capped buttes. b. Upraised basalt benches, Blackfoot Cañon.

is reached in about four miles from the mouth of the creek, and it is broken through at this point by a narrow gorge, which is walled in by precipitous exposures of Carboniferous limestone, dipping at angles of 40° to 60°, southwestward. A short distance to the northward of the Wolverine Cañon the limestone ridge ceases, the volcanics rising up all around the northern end of the range, where the edges of the upraised basalt are shown in abrupt benches facing the range and sloping off toward the plain in a series of broad, gentle terraces. The cavernous rocky ridge harbors multitudes of rattlesnakes whose magnanimous alarm was a continual warning to exercise wariness while prosecuting geological studies in their neighborhood.

The Wolverine opens out into a beautiful little mountain-basin wedged in between the two branches of the range, on the south bounded by rugged, wooded hills, which send down sharp spurs, and on the north undulating grass-covered slopes interspersed with groves of aspen descend from a high ridge on the north in which obscure indications of limestone ledges and heavy masses of vesicular trachytic lava are seen. This basin is about 2 miles across. To the northeast an isolated cluster of hills culminates in Blackfort Peak, the whole southwest flank of which is plated with several hundred feet thickness of limestone and siliceous beds, probably belonging to the upper measures of the Carboniferous. The outcropping edges of the several ledges form the crests of so many spurs descending from the summit and in the southwest flank of the mountain, cut by narrow ravines with intervening broad ridges which fall steeply into the valley over the inclination plane of the beds. On the northeast side the mountain descends even more abruptly, the face being broken by outcropping edges of limestone, into a deep valley which separates it from the low outlying hills in that direction. Hence it is seen that the Blackfoot Peak forms the crest of a monoclinal whose axis lies in a general northwesterly and southeasterly direction, the strata varying in strike from W. 35° N. to N. 15° E., and dipping westerly and southwesterly at angles of from 25° to 45°, even becoming more steeply inclined toward the southwest foot of the mountain. The section observed at this locality exhibits the following series of strata, the accompanying diagram connecting the two great spur-branches of this part of the range along a line E. N. E. and W. S. W.

Section across the Blackfoot Range through Blackfoot Peak, Station VI.

1. Bluish limestone *débris* in slopes of ravine southwest foot of Blackfoot Peak.
2. Intensely hard dark bluish-gray hornstone, standing nearly vertical, and crossing the foot of the mountain in a N. W. and S. E. direction. The ledge sometimes weathers in two parallel combs, perhaps 10 feet in thickness, and which may be traced some distance, appearing like a dike thrust up in the surface of the slope.
3. Buff siliceous *débris*, or quartzitic fragmentary sandstone.
4. Bluish-gray siliceous limestone, containing small crinoidal columns; a heavy ledge, dipping southwestward at an angle of 45°.
5. Buff and bluish, fragmentary siliceous beds or quartzitic sandstone, forming a heavy bed.
6. Bluish-gray, heavy-bedded, spar-seamed, cherty limestone, interlaminated with buff siliceous layers, containing obscure traces of fossils, *Spirifer*, *Hemipronites*, *Athyris*. This set of beds rises up into the summit of Station VI, where they incline at an angle of 35°, S. 35° W. At a lower level on the northwest spur, the same beds dip 45°, W. 15° S.

7. Gray, spar-seamed limestone, appearing in the northeast face of the mountain in successive low mural exposures.

The vertical thickness of the beds exposed in Blackfoot Peak is difficult to estimate with a degree approaching nearer than a rough approximation; but it probably amounts to above 2,000 feet, including the upper siliceous horizons of the Carboniferous, but not showing the superimposed "red-beds," or Trias, but which, it is believed, may exist between the two main ridges of the range at this locality. The connection of the beds occurring in this eastern ridge with the Carboniferous ledges which make up the west or Wolverine ridge was not actually traced, the intervening space in the upper basin of Wolverine Creek showing no outcropping ledges from beneath the detrital materials which compose its rounded, grassy slopes; but it seems highly probable that the beds composing the latter ridge occupy a lower stratigraphic position than the crest-ledges in Blackfoot Peak, and to account for their present relative position it seems within reason to infer either the existence of a line of dislocation of the strata, or, perhaps, a fold, the axis of which lies within the area included in the depression of the upper basin of the Wolverine. The latter supposition is hinted in the section across the range along the course of the Wolverine, given in an accompanying diagram, and it would appear to be the more plausible of the two inferences in explanation of the stratigraphic relations of the east and west ridges.

The view from Blackfoot Peak, which is rather conspicuous from its isolation than on account of its relative height, is both extensive and very fine. Although our first view of the Tétons was had from Mount Putnam, nearly 30 miles to the southwestward, from the present mountain the first objects that arrest the attention are the great obelisks which dominate our district and which rise up grandly away to the northeastward 60 miles distant, their pedestal of mountain plateau, at this season of early summer, showing nearly an unbroken field of snow, above which the bare rocky cones spring to heights 12,000 to near 14,000 feet above the sea. Intervening, the lower range of the Snake River Mountains hides the great foreland slopes of the Téton Range, and nearer still a belt of wild, broken hills, and a broad basin-depression with isolated low ridges, mark the position of the Caribou Range and Willow Creek basin, which occupy the country between the Snake River Range and the Backfoot Mountains. The northern termini of all these mountain and hill ranges present the volcanics gently upraised in successive benches, which sweep down in graceful curves into the great plain of the Snake, the same on the Blackfoot Mountains as on the Caribou and Snake River Ranges and the lesser ridges in the foreground. To the south the wooded ridges of the southern continuation of the main ridge of the Blackfoot Range shut out the view and a clearer exhibition of the geological features alike.

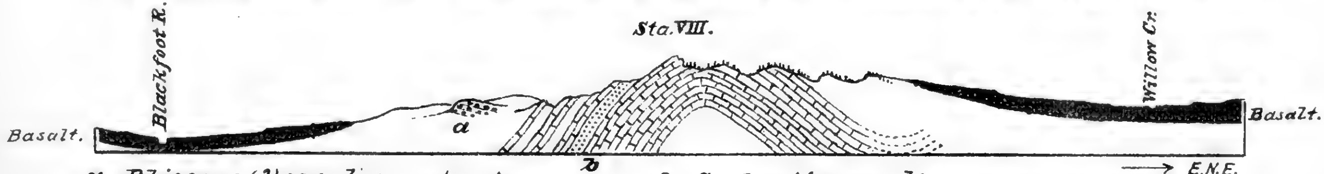
In the foreground just to the east of Blackfoot Peak occurs a narrow belt of low ridges, in whose southwest slopes obscure outcrops of soft yellow-buff deposits interlaminated with harder layers, occur, overlaid by variegated pale-reddish clays in bands, dipping off to the northeast at a moderate angle of inclination, and making up a thickness of several hundred feet. In the absence of fossils it may be a matter of conjecture in assigning these deposits to their proper place in the geological scale, while their relations to the Carboniferous beds in the monoclinal ridge from whose foot they incline is enveloped in some uncertainty from the same cause. They are believed to be the equivalent of certain deposits, possibly representing early Tertiary or Laramie Group beds; but their position in relation to the well-determined age of the beds in the mountain crest is

PLATE XIII.

A. Section across northern end of Blackfoot Range, through Station VI.

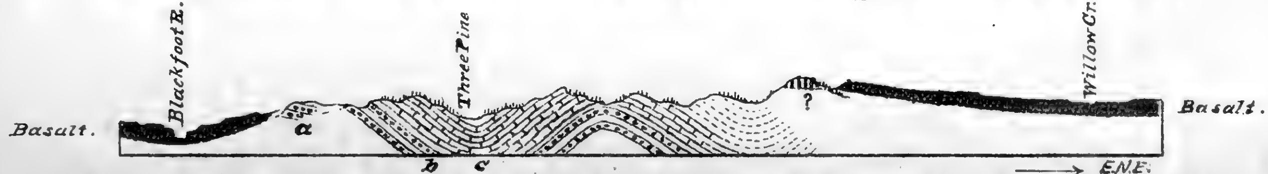
a. L. Carb. limestone. b. Wolverine basin. c. U. Carb. deposits. d. Variegated beds, Laramie?
e. Porphyritic trachyte.

B. Section across the Blackfoot Range, through Station VIII.



a. Pliocene (?) conglomerate, etc. b. Carboniferous limestone and sandstone.

C. Section across the Blackfoot Range, vicinity of Three-Pine Cr.



a. Pliocene (?) conglomerate, etc. b. Quartzite conglomerate, U. Silurian? c. Carb. limestone.

Scale: 500 ft. 4 miles. Base line 5000 ft. above sea-level.

not so clear. Their tilted condition points to a time of elevation, but whether it was contemporaneous with that which uplifted the Carboniferous beds, or whether it marks a later period of elevation in the range or subsidence in the basin area along its eastern foot, our examinations failed to show. To the south, where we touched the range, the slopes lie over *débris* and volcanic deposits which effectually conceal the underlying rock strata, until gaining the higher portions where the Carboniferous again appear, and which constitute the bulk of the range throughout.

South of the Wolverine gorge, 4 or 5 miles, the range is again cut by Elder Creek Cañon, a branch of which also rises in the range just south of Station VII, in which similar exhibitions of Carboniferous limestones were observed. In the summit of Station VII a thickness of a hundred feet or more of dark bluish and gray, spar-seamed, cherty limestone is exposed, the ledges dipping west of south at an angle of 30° to 40°. To the north the strike seems to trend more to the northeast, at one point noted, E. 15° to 25° N., the strata uniformly dipping to the southward at angles ranging from 25° to 40°. A heavy, even-bedded, dark bluish-gray, rather coarse, even-textured limestone, with drab thin-bedded or shaly partings, forms the upper 50 feet of the summit, and is charged with fossils of a Lower Carboniferous facies, a large and small species of Zaphrentoid corals, *Chætetes? Stictopora, Fenestella, Polypora, Spirifer*, &c. On the surface of a layer only a few feet below the crest, exposed in a narrow shelf on the northeast side of the ridge, a few species of Selachian teeth were found, representatives of the genera *Antliodus, Petalodus, Cladodus, Helodus*, and fragments of *Deltodus*. The discovery of the latter fossils, forms with which I had previously acquired some familiarity, was like meeting old acquaintance; and to one familiar with the occurrence of similar remains in the Lower Carboniferous rocks of the Mississippi Valley, their presence here afforded nothing in contrast with their abundant prevalence and association in some of the lower members of the earlier period of the Carboniferous in the region of the Upper Mississippi. Indeed, the occurrence of the fossils, as also the lithological character of the rock, to say nothing of the specific relations of the corals, mollusks, and fishes, is so like what obtains in the Keokuk limestone of the east as at first thought to preclude the supposition of mere resemblances instead of actual identity. But, unfortunately, it was not possible to ascertain with precision the exact position of these deposits in the few thousands of feet which sum up the thickness of the Carboniferous rocks of this region; more than that the present beds undoubtedly occur low in the series, and their contained fossils have not as yet afforded a single form peculiar to the Upper or Coal-measure division as it is recognized in the Western States. In the instance of the fish-remains above alluded to, the facts are still more strongly in favor of the Lower Carboniferous age of these beds; one of the genera, *Antliodus*, being confined in its vertical range to the lower division, while of the other forms found not one is referable or even nearly allied to Upper Carboniferous species.

The whole southwest slope of the mountain at this locality is composed of a facing of Carboniferous limestone. The steep slopes lower down are strewn with more or less water-worn *débris*, consisting of limestone, reddish sandstone, and quartzite pebbles, which in the debouchures of the little streams are molded into terraces. At the foot of the ridge the country rapidly slopes away and soon enters the region of the bordering volcanics which fill the Blackfoot Valley at this point, and which rise in long, grassy ascents into the smooth, rounded hills capped by trachytes

which show here and there in reddish fragmental ledges. The country is covered with a brownish-buff soil, which sustains a good growth of excellent herbage. Little streams of pure water flow down from the range, opening into pretty intervales bordered by willows and ponded by beaver-dams. We were inclined to imagine it a sort of Arcadia, in which the rough duties of our every-day life were blended with unexpected exhibitions of latent sentiment, transforming the camp into semblance of home, which with regret we daily abandoned, only to find the next spot equally pleasantly selected and our evening board decorated with charming floral displays, the welcome almost daily prepared us by our young men.

Between Stations VII and VIII the crest of the range trends more to the southeast, and is broken down in a wide recess which opens southwesterly into the Blackfoot Valley, and which is filled with smooth, wave-like hills, which rise in successive benches and culminate in trachyte-crowned summits but little lower than the crest of the main range. One of these eminences, situated in the mouth of the recess, and nearly in line with and almost midway between Stations VII and VIII, consists of brownish-red and drab trachytic rock, which occurs both in large blocks, rounded by atmospheric action, exfoliating in concentric layers, and in thin, even-bedded layers, which gently incline north-northeast. The break drains west by Elder Creek, and south by a similar affluent, Gravel Creek. To the northwestward, the sections exposed in the ravines show the limestone strata in nearly horizontal position, or gently inclined from east to west; but this appearance is due to the course of the cañons following nearly the direction of strike of the ledges, which are elsewhere observed to dip in a general southwesterly direction at angles of from 25° to 60°. Ascending the southern continuation of the range, at a point to the northwest of Station VIII, where Gravel Creek enters a part of its course sustained by a huge retaining-wall of limestone, through which it breaks near the foot of Station VIII and flows out southwesterly into the valley, the Carboniferous beds again appear in force, grayish-blue, spar-seamed limestone, with crinoidal columns and *Zaphrentis*, dipping W. 5° S., at an angle of 30°. The same beds form the wall along the west side of the creek, in which they appear in horizontal lines conforming to the strike of the strata, and weathered in picturesque castellated forms, pierced with caverns and apertures. The mountain slopes steeply to the stream, its face buried beneath the angular *débris* fallen from above. A little farther to the southeast these strata have trended round more to the west, dipping 35°, S. 35° W. In the saddle, a short distance northwest of Station VIII, the axis of a fold lies near and parallel with the crest, the beds dipping on the one hand 15° to 25°, N. 25° to 35° E.; and nearer the station the crest is formed of ledges abundantly charged with a form of *Lithostrotion*, *Zaphrentis*, &c., and dip S. 30° W., at an angle of 40°. Standing on any part of the crest in this vicinity, the wavering direction of the strike of the rocks is plainly traced, curving in and out, the angle of inclination gradually steepening, until, on the southwest flank, it reaches nearly 60°, S. 50° W., but so variable, even in this short distance, that only the aggregate of many observations give the mean of the rate of dip and direction of strike of the ledges which make up the mountain ridge. Descending from Station VIII, in the south end of the low ridge confining Gravel Creek to the foot of the mountain for a part of its course, and just south of the point where the stream forces a passage through to the valley, an interesting example of cleavage is seen, which at first sight might be mistaken for the bedding. The limestone rises up in a steep face, front-

ing the neighboring mountain slope, as though the beds had been suddenly upturned or overturned, the weathered cleavage structure being so marked as to give force to the deception; but a careful examination reveals the true planes of bedding, which, though obscure, agree with the general southwesterly inclination of the strata in the adjacent mountain declivity. The fossils noted in these beds consist of crinoidal remains, two or more species of *Zaphrentis*, a *Lithostrotion*, resembling *L. proliferum*, though distinct from that form; *Spirifer*, and *Euomphalus*. The limestone is interlaminated with dark cherty bands, and more or less intersected by seams of calc-spar; at one point on the southwest shoulder of the main ridge it shows an intercalated pale-reddish sandstone bed, the presence of which is regarded as indicating the approach to the upper member of the series, as it seems to be developed in this region.

After emerging from its cañon, the course of Gravel Creek crosses a belt of rolling, grassy foot-hills, which form rather steep bluffs along the stream 200 to 300 feet in height, and which are made up of a curious aggregation of coarse materials arranged in more or less distinct layers and inclining at a moderate angle, 15° to 20°, in the direction of the mountain barrier, rising to the southwest and terminating in low, rounded domes or ridges. These deposits are made up of an aggregation of more or less abraded fragments of reddish sandstone, drab, and dark-blue Carboniferous limestone, pebbles of white calc-spar and chert, held in a matrix of very fine pinkish paste. Where it shows in heavy, weathered masses, it presents the appearance of a breccia-conglomerate, the materials being arranged in courses. Sometimes the coarse materials are replaced by the pinkish paste, which often weathers away leaving miniature caverns. These deposits appear to have some connection with the volcanics of the vicinity, and from the nature of the cementing material or matrix it seems very probable that their relations are more intimate with the trachytes than with the later basaltic flows, a sort of volcanic conglomerate laid down in water.

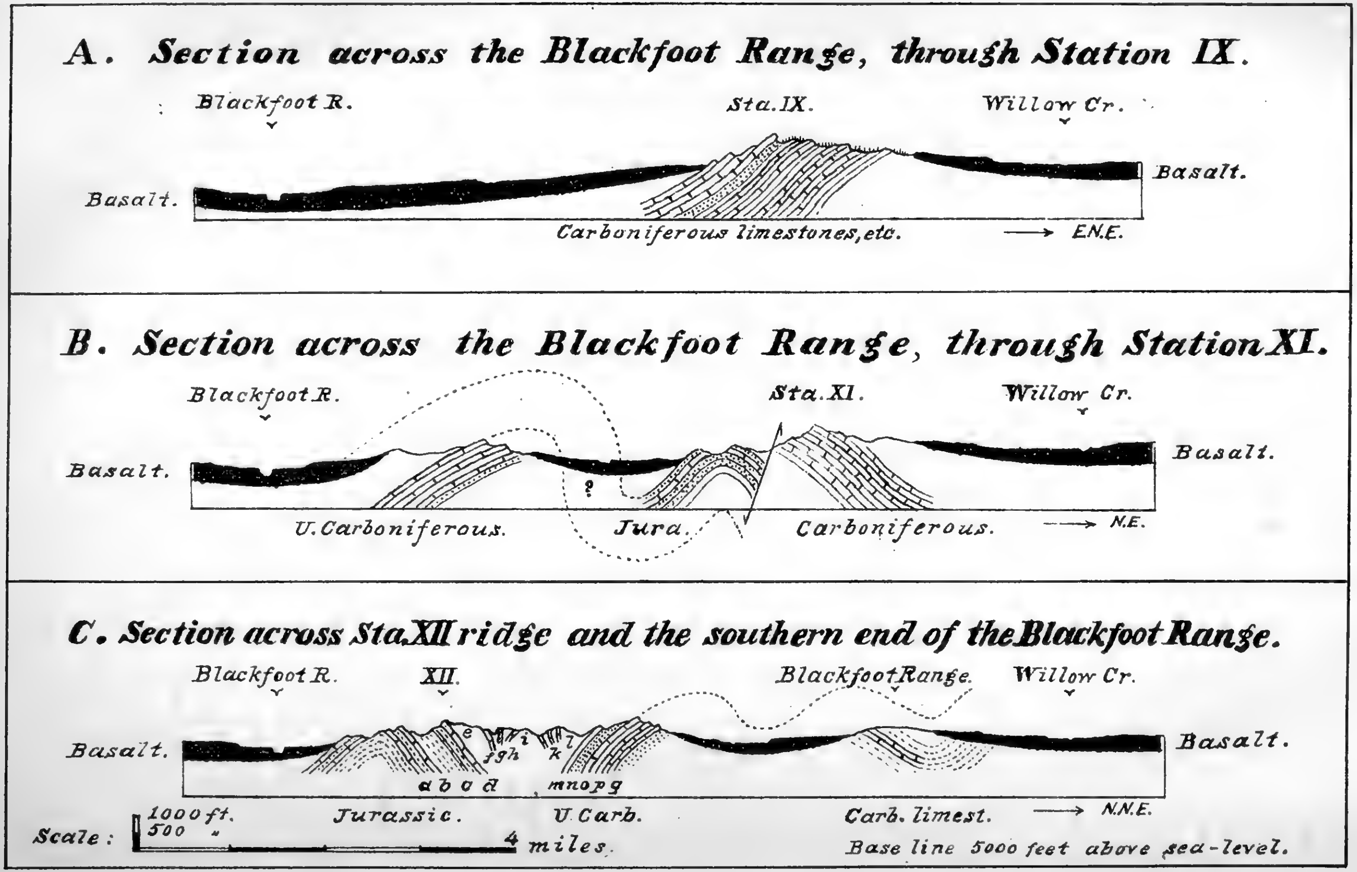
Immediately southeast of Gravel Creek a shallow trough skirts the foot of the range, gradually deepening its bed for a distance of two or three miles, when it enters a defile between limestone ridges, in which the strata incline away from the mountains southwesterly. The glade-like upper portion of the little valley occupies a trough whose outer rim is formed by the gently southwesterly upraised breccia-conglomerate, and whose surface of fine soil still retains traces of numerous but long-abandoned buffalo-wallows, and an occasional bleached, half-inhumed skull. After continuing its course in a monoclinal trough between the Carboniferous limestone ridges a distance of a mile or so, it receives an affluent from the mountains and suddenly bends southwesterly, and thence for nearly a mile it pursues its course, choked with beaver-dams, directly across the barrier ridge, and emerges into the valley. Soon after entering this lower gorge the limestones are observed to dip northeastwardly at an angle of 30° to 40°, the strata holding the same inclination to the debouchure, where the lower deposits are conglomeritic, which latter shows a low outlier on the west side of the stream a little lower down. Still below, the breccia-conglomerate again appears in the steep bluff acclivities, the latter deposit also dipping northeasterly. These latter deposits are here also accompanied by the peculiar rounded, bluffy, superficial features before mentioned as characteristic of these beds, and it is further notable, in explanation of the relative age of these supposed, in part at least, volcanic deposits, that as soon as we gain the higher slopes just to the southeast the surface is

based upon the dark steel-gray basalt which farther on impinges directly against the limestone in the foot of the mountain at Station IX, overlying or filling eroded depressions in the breccia-conglomerate. The basalt slopes gradually to the westward towards the Blackfoot, forming the walls of the cañon in which the stream is inclosed along this part of its course. The upland basaltic slopes are generally covered with a finely-pulverized brown soil, which nourishes good pasturage. Occasionally on some of the higher tables areas of bare, rough-weathered basalt occur, strewn with more or less weathered bowlder-like masses of the same rock. We do not again meet with the breccia-conglomerate nor trachyte after leaving the Three-Pine Creek Cañon, the basalt thence continuing southeasterly all along the southwest foot of the range into the upper basin of the Blackfoot. But the recess which penetrates and cuts quite across the range in this vicinity and just northwest of Station IX, and which marks the site of an anciently-eroded depression across this part of the range, is filled with herbage-covered hills, whose peculiar imbricated contour, sloping in the direction of the Blackfoot, recall the characteristic surface-features associated with the breccia-conglomerate, as before noted on Three-Pine and Gravel Creeks. Farther within the recess, and nearly in line with Stations IX and X, a sombre, massive, rounded hill forms a rather prominent landmark in the sag of this part of the range, and which is probably also of volcanic origin. In this connection should be remarked the resemblance of the above-mentioned breccia-conglomerate deposits to certain deposits met with west of the Blackfoot, near our southern border, described in a preceding page, and which will probably prove to be identical, and possibly these deposits are the equivalent of the interlaminated Pliocene and porphyritic trachytic beds mentioned by Professor Bradley outlying the Putnam ridge north of Ross Fork on the border of the Snake plain.

To the southeast of Three-Pine Creek Cañon the range gradually diminishes in height, the southwest face still retaining its abrupt character, the opposite side of the range falling down over a series of parallel wooded ridges into the volcanic slopes of the basin to the northeast. In the southwest flank of the ridge, at Station IX, a fine exhibition of the Carboniferous deposits is met with, the beds lapping up on the mountain-side and showing a series of dark bluish-gray limestones, with irregular nodular masses of black chert and spar seams, and containing *Ctenacanthus*, crinoidal columns, *Zaphrentis*, *Lithostrotion*, &c. The beds in this section exhibit quite variable direction of strike and degree of inclination, scarcely two exposures agreeing, although showing a near approximation to a dip ranging from 25° to 40°, S. 40° W.; the variation in strike ranging from S. 10° E. to S. 50° W., as determined from exposures near the crest and in the outlying ridges to the northeast, while at other points in the west slope the beds locally dip at various angles, 45° to 70°, S. 10° W. On the southwest slope, however, the beds are much intersected by cleavage and joint structure, greatly obscuring the true bedding, which at few points is satisfactorily revealed. To the northwest of the station an intercalated bed of pale-reddish, fine-grained, laminated sandstone, almost a quartzite, shows in much broken up exposures, which hold a position beneath the limestone occurring in the crest at the station. As before mentioned, the basalt of Blackfoot Valley is seen but a short distance from the foot of the mountain, and it doubtless impinges against the limestones at this point. To the northeast similar basaltic flows rise even higher on the flank of the mountains on that side, concealing the character of the sedimentaries in that quarter.

From the summit of Station X, which occupies the highest southern

PLATE XIV.


A. Section across the Blackfoot Range, through Station IX.
Blackfoot R.
Sta. IX.
Willow Cr.
Basalt.
Basalt.
Carboniferous limestones, etc.
→ E.N.E.
B. Section across the Blackfoot Range, through Station XI.
Blackfoot R.
Sta. XI.
Willow Cr.
Basalt.
Basalt.
?
U. Carboniferous.
Jura.
Carboniferous.
→ N.E.
C. Section across Sta. XII ridge and the southern end of the Blackfoot Range.
Blackfoot R.
XII.
Blackfoot Range.
Willow Cr.
Basalt.
Basalt.
e
fgh
i
k
l
abcd
mnopq
Jurassic.
U. Carb.
Carb. limest.
→ N.N.E.
Scale:
1000 ft.
500 "
4 miles.
Base line 5000 feet above sea-level.

point of the range one mile southeast of Station IX, from which it is separated by an intervening depression, a comprehensive view of the range to the northwest is gained, sharply bringing out the volcanic-filled recess between Three-Pine Creek and Station IX, and a wide belt of the range stretching between Station VIII and Blackfoot Peak, more to the north. On leaving the basaltic bench, in the southwest foot of the ridge three-fourths of a mile from the summit occurs a heavy deposit of fragmentary buff siliceous rock, interbedded with bluish and gray spar-seamed and sometimes brecciated limestone beds, succeeded nearer the crest and in the northeast slope by siliceous limestones, which make up the entire bulk of the ridge. The limestones afford characteristic Carboniferous fossils. The prevalence of minute forms, chiefly Gasteropoda and a few Lamellibranchs, strongly recalling the faunal characteristics of the Warsaw beds of the Lower Carboniferous in the region of the Upper Mississippi. There was also found here in some numbers a minute Foraminiferous form, which is quite unique. The section of these deposits in Station X ridge reaches a vertical thickness of above 2,000 feet. Although exhibiting local eccentricities which indicate that the beds have undergone a degree of crumpling, the inclination of the strata is quite uniform to the northeastward, or ranging from 15° to 70°, N. 10° to 70° E. Looking toward Station IX ridge from this point, it is evident that the strata in Station X belong to the northeast flank of a fold lying to the southwest of that which runs through the former station, and that the intervening depression occupies the position of a synclinal, which may correspond to the synclinal depression observed along the upper course of Three-Pine Creek, before referred to.

Passing along the mountain ridge to Station XI, 2¼ miles to the south-southeast, the same series of upper limestones continue, showing the same general inclination, or dipping at an angle of 30° to 45°, N. 15° to 75° E. In the crest at Station XI the rock is a rough weathered blue and gray silicious limestone, bearing Producti and *Stictopora*, and dipping 30°, N. 20° E. This point is about the last high eminence on the range, to the southeast of which the country rapidly approaches the condition of a low divide, which projects southward into the basin of the Blackfoot. Descending the southwest flank of the ridge, two lower parallel ridges are crossed before gaining the basaltic plain, in the first of which appears a brown-stained grayish limestone and fine indurated arenaceous shaly layers, containing obscure casts of Lamellibranchs (*Aviculopecten?*), *Lingula*, &c., the strata inclining at an angle of 30°, N. 45° W. But in the spur just to the westward, corresponding to this ridge, the same ledges are tilted to a nearly vertical position, or dipping 80°, N. 30° E. These ledges are traced some distance along the face of the ridge, the strike curving in and out, and often forming low combs or hog-back outcrops, the extent of the exposure reaching several hundred feet, though difficult to determine with accuracy. The outlying and but little lower ridge, which is less than half a mile distant from the former, is apparently made up of similar deposits, showing brownish-red shaly sandstone and dark, slightly-gritty limestone, which, in the southwestern slope, facing the valley, dips 45°, S. 20° W. Hence, in passing from one ridge to the other, the axis of an abrupt anticlinal fold is crossed. Such evidence as is afforded by the poor condition of the fossils and the lithological pecularities of the beds above described seems to leave little doubt as to their Jurassic age; but to account for their position in relation to the Carboniferous ledges which form the mass of the main mountain ridge against which the Jurassic beds impinge, holding nearly the same inclination along the northeast flank of the anti-

clinal, recourse must be had to something more than mere folding of the strata, a force which severed their stratigraphic continuity by a fault, with a downthrow on the southwest amounting probably to at least two or three thousand feet. The strata in the adjacent mountain-crest may be safely regarded as holding a position below the middle of the Carboniferous series, as developed in this region, and the downthrow has involved the remaining upper portion of the Carboniferous, the whole of the Trias, and the lower measures of the Jurassic. Tracing the course of the fault, it apparently soon runs out into the Blackfoot Valley to the northwest, while in the opposite direction it skirts the southwest flank of the Blackfoot Range and disappears beneath the volcanics which envelope the southern terminus of the range.

Passing around the southern end of the Blackfoot Range, our way led up over a highish platform of basalt, which appeared in rugged, sombre exposures, and at one point presented the appearance of a cascade, the igneous matter, as it were, having overflowed a depression from the eastern basin, forming a connection with the flow that filled the Blackfoot Valley. This locality may be in the neighborhood of three miles southeastward of Station XI. Immediately to the south, in the summit of the low divide in which the range is continued a little farther, the bluish-gray spar-seamed Carboniferous limestones show in limited exposures, dipping off to the northeast; and still farther to the southward, in the extreme end of the divide facing the upper basin of the Blackfoot, at a later date of our visit similar deposits were observed to form a synclinal, the axis of which lies a little to the southwest of the crest of the divide, which here rises in a gentle swell but little elevated above the higher benches of basalt which lap up on and surround the sedimentaries.

From such data as we were able to obtain, it is apparent that this little mountain range possesses a geological history not so simple as might at first appear. Examined at one point, its structure might be interpreted as a simple monoclinal ridge, resulting from the degradation and complete removal of the opposed side of an anticlinal fold; again, it shows a similar structure, but which is clearly due to faulting and a consequent downthrow of many hundred feet; and elsewhere its principal ridge conforms to the axis of greatest elevation at one point, and at another the reverse is true, where the crest occupies the axis of a synclinal. And with all this diversity, which might be readily deciphered in detail otherwise, there are associated entirely different geological products, which, at a date so modern as to have been introduced at a time when the range had received nearly its present configuration, half buried its flanks and crept into and filled its valleys with flows of molten rock from volcanic sources to such an extent that their remnants as found to-day greatly embarrass the study of the dynamic history of the range, not only by hiding beneath their rigid surface the buried sedimentaries, but completely isolating this narrow zone from contiguous and similar areas of disturbance, the inception of which long antedates the manifestation of this widely extended and comparatively modern epoch of volcanic activity.

There remains to be mentioned a small area of isolated hills lying between the Blackfoot River and the Blackfoot Range, which is apparently quite cut off from connection with neighboring highland areas by the basaltic flow which fills the Blackfoot Valley. Without showing a distinct topographic crest or ridge, yet this area has a well-defined drainage axis, which was marked out by the nature and position of its rocky foundation. The strata were found to strike pretty uniformly about E.

35° S. by W. 35° N., varying to an east-southeast and west-northwest course, and inclined at various angles to the north and southward, the drainage generally following lines corresponding to, and in many instances dependent on, the strike of the beds, or both. The southern and southwestern portion of the area is composed of Jurassic deposits, consisting of gritty limestones, indurated arenaceous beds, and variegated red and chocolate colored shales, certain layers being charged with an abundant and characteristic fauna. These deposits, which make up a vertical thickness of several hundred feet, are here thrown up in a great fold, the southwestern flank of which extends to the west of the Blackfoot, as mentioned on a preceding page, where that portion of it which lies within the present district is buried beneath the late Tertiary, or Lake beds, and the volcanics. Immediately the well-determined Jurassic fossiliferous beds which appear in the steeply-inclined northern flank of the fold are left, a belt of above a mile across is so enveloped in superficial detrial material, intermingled with pinkish trachytic *débris*, as greatly to obscure the underlying basis structure. But from such data as the few and more or less obscure exposures met with in this belt reveal, it is apparent that it embraces the site of extraordinary disturbance, the harder ledges, consisting of limestones and quartzose sandstones, with traces of more extensive interbedded deposits of red sandstones and sandy shales, are inclined at steep and varying angles, and in places tilted past the vertical or wedged in between sharp synclinal flexures. About two miles north of the axis of the Jurassic fold, the southern foot of the ascent to a high dominating point is mailed by a heavy ledge of light-drab and flesh-colored, siliceous, brecciated limestone, containing traces of indeterminable fossils, and dipping 60°, S. 20° W. In the saddle and cañadas which drain in either direction, east and west, deep-red gritty clays appear, and in the ridge to the south a short distance, several ledges of thin and heavy-bedded gray limestones, associated with brown, laminated, earthy, indurated layers, both of which show obscure traces of fossils, *Ceratites*, &c., occur, steeply dipping to the north, or vertical. The outlying heavy limestone ledge is succeeded on the north by a still heavier pale reddish-buff siliceous deposit, which rises in gradually decreasing steepness up into the plateau summit, which abruptly terminates in a parapet of clinking, fragmentary, pinkish-gray siliceous limestone, dipping S. 38° W., at an angle of 45° to 50°. The northern face of the little plateau falls quite rapidly over a series of sparsely wooded benches, in which successively appear ledges of gray, siliceous, and cherty limestones, with small *Zaphrentis* and *Syringopora*, crinoidal remains, *Productus semireticulatus* and *P. longispinus*, the beds dipping 45°, S. 20° W. The latter beds, at least, pertain to the Carboniferous, and the few fossils observed belong to species prevalent during the later period of that age. The detail section of the strata above alluded to, commencing at Station XIII ridge, and thence carried northward to the higher Carboniferous ridge, is as follows:

Section north of Station XIII ridge.

a. Brown, shaly, indurated, fine, areno-argillaceous deposit with dendritic markings, with thin layers of brown chocolate-gray limestone, sometimes spar-seamed, and containing a small terebratuloid shell and *Discina?* Apparently a heavy deposit, 300 feet or more in thickness.

b. Brown-gray, thin-bedded, spar-seamed limestones, with intercalated thin sandy layers, forming a heavy ledge in the crest of Station XIII ridge, opposite Station XII, and plating the northern slope in places;

dip 50° to 65°, N. 15° to 40° E., charged with a minute *Pseudomonotis*, medium-sized *Aviculopecten*, *Terebratula*, *Lingula*, &c. Specimens of a similar limestone, filled with the same fossils, the handsome little *Pseudomonotis* occurring in great numbers, were brought me by Mr. Tom Cooper, from Station XIII, a couple of miles west of Station XII.

c. Buff and brick-red indurated arenaceous shales, with thin, shaly limestone band, exposed 200 to 300 feet, but much thicker, and filling the cañada between the ridges of Stations XII and XIII, which are here about a third of a mile apart.

d. Dark brown-gray, fragmentary, slightly arenaceous limestone, a rather heavy ledge occurring in the crest of Station XII ridge; dip 50°, N. 15° to 70° E. This rock contains numerous fossils, *Lingula*, *Terebratula*, *Aviculopecten*, a large and small *Pseudomonotis*, *Myacites?*, &c.

e. Grassy, undulating upland, with light-red or pink trachytic *débris* scattered over the surface, but no rock exposures *in situ* observed over a space of about one-third mile in width, north of Station XIII ridge.

f. Gray, buff-mottled, fine-grained, spar-seamed limestone, with cherty bands, apparently a thick bed; dips 75° N., 30° E.

g. Heavy ledge, reddish-buff, very hard, fine-grained sandstone, standing vertical, or slightly inclined from vertical north, exposure 50 yards north of last above bed. The outcrop shows angular fragments, and intersected by joint structure.

h. Dirty gray, thin-bedded, spar-seamed limestone, *débris* exposure, not showing ledge *in situ*. It is succeeded a few yards north by a ledge of very hard dark-gray limestone, containing an obscure fossil resembling *Aviculopecten*, but too indistinct for identification; dips 45° to 50°, S. 35° W.

i. Reddish sandstone and arenaceous shales. A much broken-up exposure in crown of ridge, perhaps one mile north of Station XIII ridge, and apparently filling the narrow depression or cañada just to the north, out of which it is eroded.

k^1. Thin-bedded dark-gray limestone, with minutely comminuted fossils; dips 55° to 65°, N. 35° to 40° E. Exposed in south slope of ridge, perhaps a quarter of a mile north of crest of sandstone ridge. Above occurs the following ledges:

k^2. Heavy beds of gray limestone, associated with brown, laminated earthy, indurated layers, slightly inclined from the vertical northward, although the exposure is but a few yards removed from the preceding bed. This ledge contains an obscure Lamillibranch and fragments of *Ceratites?* and it forms a marked feature in the south-facing slopes, where it may be traced for a distance to the southeastward and northwestward.

k^3. Thin-bedded gray limestone, exposed but a few yards north of last above-mentioned ledge; dip almost vertical, or at a steep angle to the south.

l. In the saddle of the narrow cañada a short distance north of the last ridge, red shaly deposits are seen in washes.

m. Flesh-gray limestone, with pink chert layers, 8 feet; overlaid by a heavy deposit of gray, fragmentary, brecciated, siliceous limestone, 100 feet or more; dips 60°, S. 35° to 40° W. Contains fossils, but too imperfect for identification. This ledge forms a heavy plating to the south-facing slope of the culminating plateau, two and a half miles north of Station XIII ridge.

n. A vertical space of 200 feet or more without exposures follows, and then a heavy deposit of siliceous matter is met with, rising up into the high ridge. It is composed of reddish, pink-mottled, buff, gritty beds, the decomposition of which produces a reddish-brown soil, underlaid by

white quartzitic sandstone and buff, fragmentary siliceous layers, which latter rise high up in the surface of the hill, gradually flattening out in their southwesterly inclination, and probably attaining a thickness of several hundred feet.

o. Clinking, fragmentary, thin-bedded, siliceous limestone, fleshy-gray; weathers rusty reddish-gray, becoming very cherty below, and interbedded with fine drab limestone. A heavy ledge in crest of ridge, dipping 45° to 50°, S. 25° to 30° W. Small pentagonal discs of crinoidal columns, in the chert, were the only fossils observed.

p^1. Immediately underlying the above bed occurs a ledge of dark gray, brittle limestone, with a Zaphrentoid coral, *Syringopora*, *Athyris subtilita?* This is followed by—

p^2. Gray, gritty, hard, laminated limestone, which is in turn underlaid by—

p^3. Gray, cherty limestone, containing *Productus longispinus*, *P. semireticulatus*, &c.

p^4. Several beds of bluish-gray, spar-seamed limestone and cherty limestone, with *Syringopora*, crinoidal remains, &c., and cherty masses showing a concentric structure. The latter beds appear in a bench in the steep northerly slope between one and two hundred yards north of the crest, and together with the overlying beds making up a heavy deposit, dipping 45°, S. 20° W. The latter limestones are clearly Upper Carboniferous, as shown by the presence of *Productus longispinus* and *Athyris subtilita.*

q. In slope below the above limestones, in the north side of the ridge, reddish sandstone *débris* was observed, but no beds *in situ.* Elsewhere similar ledges are interbedded with the limestones in this member of the Carboniferous series. The slope below gradually merges into the basaltic benches which surround these hills and incline gently in the direction of the Blackfoot.

As before intimated, the relation of this area to the Blackfoot Mountains could not be traced for the intervention of the basaltic flow which fills the intermediate depression. The strike of the strata is nearly the same in both areas. In the latter, however, it is noticeable that the beds have swerved round more to an east-southeast and west-northwest course. The direction of the strike of these ledges extended northwesterly would intersect the equally disturbed belt in the vicinity of Higham's Peak and Station IV, with which the present much disturbed belt is probably synchronous. According to the confessedly meagre data which were obtained at this place, there would appear to exist here two sharp synclinals, separated by a narrow anticlinal fold, which is much pinched and faulted on the south. In the space where this fault would be looked for traces of trachytic *débris* were noticed, but not in quantity sufficient to suggest this as having been a point of volcanic effusion. The supposed fault indicates a downthrow to the south, probably double the total thickness of the Jurassic, or 3,000 to 5,000 feet, and it may be found to have intimate relationship with the complicated and probably faulted Jurassic strata in the border of Lincoln Valley, just to the south of Station IV ridge, with which the disturbed belt at the present locality is thought to be intimately related. The interpretation here presented of the structural features of the locality has been reproduced in one of the accompanying diagrams, representing a profile section of the locality above alluded to.

WILLOW CREEK BASIN AND BASIN RIDGES.

The southern central portion of the southwest section of the district is occupied by an extensive basin-area, which forms the low water-shed

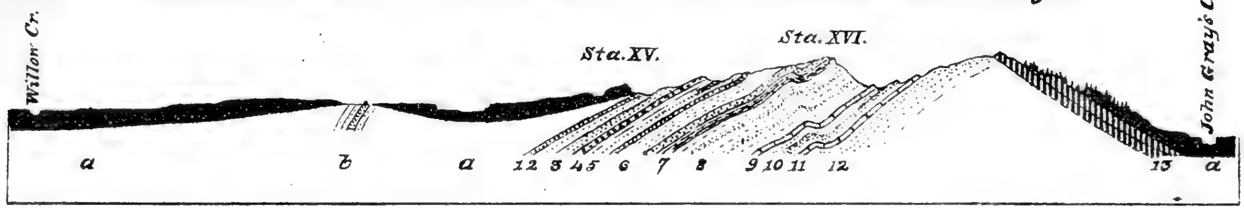
draining south into Bear River and northwest into the Snake through Willow Creek, a considerable area lying west of Day's Lake belonging to the upper basin of the Blackfoot. That portion of this basin within the present district, with the exception of the few square miles pertaining to the Blackfoot, opens out into the great plain of the Snake to the northwest, the extreme sources of Willow Creek originating in the watershed on the south boundary of the district, where John Day's Creek rises in a shallow lake of uncertain or variable extent, according to the season, its borders being occupied by extensive levels of marsh, margined by fields of tule and treacherous bog. This portion of the basin reaches an altitude of 6,400 feet; the descent to the northwest to the junction of Day's Creek with the main channel of the Willow being some 400 feet in a distance of about 30 miles, and thence to the lower level of the great plain a further descent of 1,000 feet, mainly over the great volcanic upland bench which everywhere borders the Snake plains north of Ross Fork.

The upper courses of the streams wind through shallow, meadow-like depressions between the gently undulating basaltic slopes and low plateaus, in which they begin their cañoned course lower down, and thence across the intervening broad stretch of volcanic upland. Their beds are hidden in the depths of the sombre rock until they emerge into the plain. It seems almost incredible that these deep cañons could have been excavated by the little streams which to-day occupy their beds; yet such is doubtless the fact, though the work was performed when their volume greatly exceeded its present amount. The results of erosive action in these rocks are well known. In the high, level basins of this region the waters are collected into a main channel which flows over the surface, a large proportion of its spring-fed tributaries sinking in the cavernous rock ere they reach the main stream, along which they sometimes reappear as powerful springs. But soon as the general surface begins a more rapid inclination, then the collected force of the streams is concentrated, and the work of deepening their beds is facilitated both by the lay of the country and the nature of the rocks; the one precipitating the water down rapid chutes, while the hardness of the other prevents the lateral wear beyond certain narrow bounds, and the subsequent and gentler acting atmospheric agencies which mould the flaring valley-sides in softer materials, here meet with stubborn resistance in the intractable basaltic ledges which usually form a mural cornice along the brink of the gorge.

The northeast and southwest margins of the basin within our territory are bounded respectively by the Caribou and Blackfoot Ranges. It is traversed centrally, in its longer direction, by a low highland belt, which erosion has fashioned into isolated ridges which have a parallel arrangement both in relation to one another, as also to the higher mountain borders on either hand. These mid-basin ridges attain throughout quite uniform relative elevations of 600 to 1,000 feet, and exhibit in their geologic components interesting variety. The lower levels are floored by basalt, which evidently inundated the valley in successive flows during the later epoch of volcanic activity. But besides the latter deposits, others of presumably earlier origin are met with in the shape of dikes of hornblendic trachyte, whose extrusion has tilted the sedimentary deposits through which they pass, and which latter, it should be mentioned, form the nuclei of the basin ridges. Elsewhere the crests of these disturbed sedimentary elevations are crowned by heavy flows of trachytic lava, while other elevations culminate in irregular rounded domes composed of vast quantities of scoriaceous lava. At various

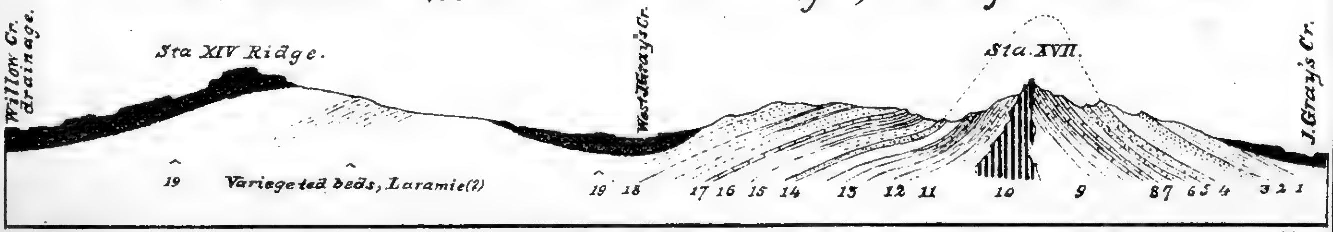
PLATE XV.

A. *Section across north end of Willow Creek Basin ridge.*



a. Basalt. b. Laramie (?) gray sandstone. 1–12 Laramie beds. 13. Trachyte.

B. *Section across Willow Creek Basin ridges, through Station XVII.*



500 ft. 19. Basalt and scoriaceous lavas. 1–9, 11–18. Laramie beds. 10. Hornblendic Trachyte.

Scale: 1 2 miles. Base 5000 ft. above sea-level.

points the basaltic lavas reach high up on these volcanic crowned eminences, where they may merge through gradations of more and more vesicular varieties into the crowning scoriaceous deposits, and sloping in every direction into the lower country. The occurrence and local aspects under which these materials are observed, as also the sedimentary formations which form the basis of the basin ridges, will be briefly noticed in the following summary of detail geology.

WILLOW CREEK BASIN RIDGES.

Situate between Willow Creek and John Day's Creek, the lowermost ridge of the basin rises rather suddenly out of the volcanic upland that slopes off its north and west flanks, and is thence continued southeasterly a distance of perhaps 12 miles, when it flattens out into the low basaltic plateau which intervenes between the west branch of Day's Creek and the sources of the Blackfoot. Nearly the whole of the southern half or two-thirds forms a broken ridge of basaltic buttes, to the north rising into the rounded culminating summit on which Station XIV was made, which attains an actual altitude of something above 7,400 feet. This elevation is covered with red and dark scoriaceous lava *débris*, but in the steeper break facing northward, heavy ledges of dark steel-gray basaltic lava appear. The southwestern slope falls more gradually, showing frequent exposures of similar volcanic ledges, dipping westerly into Willow Creek Valley, as also inclining gently in the direction of the open basin country to the south and west. This disposition of the igneous rocks suggests the sources of the outflow in the neighborhood of Station XIV, and it may be that the scoriaceous material belongs to a remnant of crater effusions in which originated the blanket of lava covering these elevations. But of crater cone, the imagination can discover in this eminence hardly more than a vague resemblance, and this mutilated by time. The extreme southern end of the ridge presents a limited tract of low, rolling hills, in whose smooth grassy surfaces obscure exposures of reddish-tinted deposits were seen, which are probably the reappearance in that direction of a similar series of deposits extensively developed in the northern portion of this ridge. These low hills, however, continue but a short distance when they are cut off by the basaltic-floored plain lying to the south, southwest, and southeast.

North of Station XIV the ridge is almost dissevered by the erosion of a little tributary gaining the east bank of Willow Creek, and which occupies a small basin bordered by grassy acclivities which sweep up into Station XIV on the south and the hills to the north which form the northern continuation of the ridge. It is difficult to decide whether the above mentioned depression is floored by the volcanics which everywhere occur in the adjacent plains. On the north side of the depression the heavy bedded basalt gently rises up on the southwest flank, where it culminates in the low cap of Station XV, 6,800 feet. But to the east the bared southern slopes, exhibiting sedimentary deposits, rise rapidly into a higher plateau, which, at Station XVI, a mile and a half north-northeast of Station XV, reaches an altitude of 7,200 feet; and about the same distance north the sedimentaries cease in a somewhat higher hill, the crest of which shows a heavy ledge of hard, drab, thin-bedded trachytic rock, dipping at an angle of 40°, N. 30° E., the north and northeast slope falling in rugged benches to the level of the basaltic upland which extends down to the cañon of John Day's Creek on the one hand, and to Willow Creek on the other.

In this latter cluster of hills an interesting series of sedimentary de-

posits is met with, showing a thickness of several hundred feet, with a general inclination of 20° to 35°, about S. 35° W. At one point in Station XVI ridge the ledges show, in their northerly dip, a short undulation, beyond which, north, they resume their southwesterly inclination as far as traced. The exposures here referred to afford the following detail section:

Section in northern portion of Willow Creek ridge, through Station XVI.

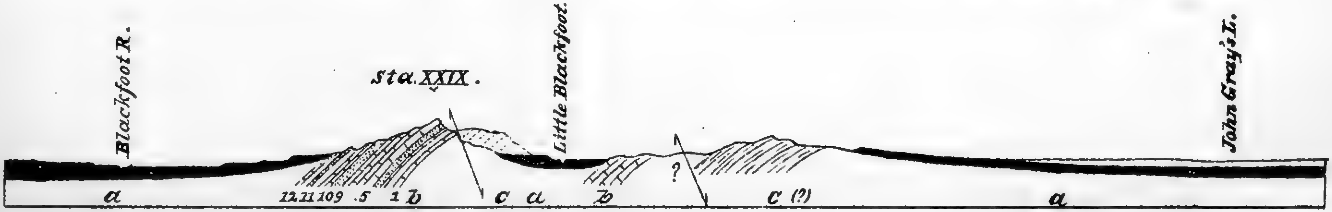
1. In the southeast flank of Station XV, 300 to 400 feet below the summit, soft, gray, laminated shaly sandstone, with obscure vegetable impressions, interbedded with reddish and light gypsiferous shales, outcrops, showing a thickness of above 100 feet; dip 28°, S. 40° W. These deposits are capped by the basalt in Station XV, there being no evidence of other volcanic deposits interposed between the basalt and the sedimentaries. The contact of the latter deposits was hidden by the *débris* accumulations at the foot of the basaltic walls, so that it was not ascertained to what extent or in what manner the contact of the igneous matter affected the sedimentary deposits over which it flowed. From the above exposure the line of the section was carried nearly at right angles to the strike of the sedimentary beds, or in a north-northeast direction.
2. The next exposure, 300 yards distant, appears as a low comb formed by a heavy bed of similar gray, thin-bedded sandstone, dipping at a little steeper angle. It is cross-bedded, the planes of false bedding facing the northeast.
3. At foot of steeper slope, 100 yards beyond the last, similar but still heavier deposits of softish gray sandstone are exposed as a plating in the acclivity, dipping at an angle of 35°.
4. In the crest of the ascent, which is determined by the strike of the beds, a few hundred yards from the foot of the last ledge, the sandstone changes to a course aggregation of water-worn but not rounded siliceous pebbles, forming a friable, thin-bedded, conglomeritic rock of a rusty buff and reddish tinge, the disintegration of which has strewn the surface with fine gravel. The estimated thickness of this ledge is about 50 feet; dip 25°, S. 40° W. The coarse materials show a variety of color.
5. The above deposit is immediately succeeded below by a heavy bed of deep-red, fine arenaceous shales, probably at least 50 feet thick, which outcrops in the southern slope of a shallow saddle, in the bed of which appears—
6. *a*, Gray sandstone, passing below into a heavy deposit made up of, *b*, gray and reddish tinged sandstone, with, *c*, interlaminations of indurated ferruginous material, reach a thickness of several hundred feet. In the summit of Station XVI plateau, the above layers are underlaid by an equal or considerably greater thickness of similar arenaceous deposits which occur in the following order: *d*, ledge of hard, buff, rusty weathered sandstone; *e*, softish buff sandstone; *f*, ledge of hard, rusty gray and brownish sandstone; obliquely and horizontally laminated, and containing obscure vegetable remains like fragments of the trunk or limbs of trees. The latter ledge shows a local disturbance, in places being raised up into low bulging or sharp crested narrow ridges, and dipping at angles of 20° to 35°, E. 25° S. to N. 5° W., but elsewhere showing general conformity with the overlying deposits. These deposits extend up into the culminating point at Station XVI, to the north of which the hill falls away over steep slopes into a deep saddle connecting it with the higher crest a mile and a half distant, in which the highland

PLATE XVI.

A. Section across Willow Creek Basin, south of Stations XIV and XVII.

a. Basalt. b. Carboniferous limestone. c. Variegated beds, Laramie (?)

B. Section across Basin Ridges between the Blackfoot and John Gray's Lake.



1000 ft 500 " 1 2 3 4 miles. a. Basalt. b. Carboniferous. c. Jura-Trias.

Base 5000 ft. above sea-level.

terminates. In this steep slope the following ledges are imperfectly exposed:

7. Dark gray calcareous gritty bed, sometimes conglomeritic or brecciated, containing numerous poorly preserved Lamillibranchs, Gasteropods, and vertebrate remains, probably fishes. The fossils are impacted in the tough matrix, from which they are obtained in so mutilated condition as to render their identification doubtful. Dr. White, however, refers one of the most prevalent forms to *Unio*, at the same time noting a resemblance it bears to forms occurring in the Laramie beds in the region to the south. The Gasteropods are indeterminable, while in regard to the vertebrate remains, which were submitted to Professor Cope, their affinities remain as yet undetermined with the exception of some small-sized gar scales which, although not specifically determinable, are probably of Tertiary age.

8. Underlying the last-mentioned stratum occurs a thickness of several hundred feet made up of red and drab gritty shales, including soft gray sandstone layers, which descend into the saddle north of Station XVI, where they rest upon—

9. Fragmentary drab limestone, forming a low debris-strewn ridge at the foot of the descent. This outcrop may be traced at intervals more or less interrupted in a southeasterly direction, reappearing in the low ridge between the forks of John Gray's Creek northwest of Station XVII, where its outcrop gives a banded appearance in the grassy slopes. It contains numerous individuals of a small undetermined Gasteropod.

10. Ascending the long slope to the north, the latter limestone is immediately followed in descending order by gray, cross-bedded sandstone, interbedded with chocolate-red shales and indurated ferruginous layers. These beds form a heavy deposit, showing local disturbance, but with a normal dip S. 45° W. at an angle of about 20°.

11. Higher in the slope the position of another limestone bed is marked by the drab, fragmentary *débris* which strews the surface. Besides a fragment of bone, there were also seen other obscure fossils. The rock is less brittle and lighter colored than bed 9.

12. Dirty and sometimes reddish-buff, very hard, brittle, spar-seamed sandstone. The rock shows slickenside surfaces, is almost the hardness of quartzite, and contains vegetable impressions like sections of limbs. Its *débris* covers the surface extending up into the summit, which is capped by a heavy ledge of—

13. Grayish-blue trachytic rock, having a distinct bedded structure, in firm, uneven layers 2 to 12 inches or more in thickness. The rock presents a low wall in the crest of the hill facing southwestward, in which the exposed edges of the layers reach a thickness of 5 to 15 feet, dipping 40°, N. 50° E.

Such as they were, the few obscure vegetable remains found in connection with the sandstones of the foregoing section were submitted to Professor Lesquereux for examination, who kindly informs me that, though too indistinct for minute determination, they are undistinguishable from similar vegetable relics prevalent in perfectly authenticated Laramie beds at numerous localities in the Northwest. This, together with Dr. White's determination of the probable affinities of the invertebrate fossils before alluded to, as well as the probable relations of the vertebrate remains communicated by Professor Cope, afford ground for referring all these deposits to the age of the Laramie Group. As we shall have become more familiar with the fauna and flora of the rocks of these distant regions, the doubts of to-day may appear almost without foundation and vanish. But these results are the outgrowth of time,

and if we succeed in ascertaining the actual stratigraphic sequence of the geological series, much will have been secured of value as well to the palæontologist as to the geologist.

A couple of miles to the southwest of Station XV, in the low grassy slopes on the west side of the little basin, a narrow ledge of soft, thin-bedded, gray sandstone outcrops in a miniature hogback ridge, dipping steeply to the southwestward, or 54°, S. 40° W. This ledge undoubtedly belongs to the same series shown in Station XVI section, and forms the outflanking exposure on this side of the Willow Creek hills. But descending, east, to the West Fork of John Gray's Creek, whose valley is flooded with basalt, and crossing over to the lower ridge embraced between the West and East Forks, the same series of deposits is again encountered, where the strata are bulged up and finally severed by the extrusion of igneous matter which forms the culmination of the ridge.

This ridge extends from the northwest in a southeasterly direction, about six miles, and parallel with the higher ridge described in a preceding page, from which it is distant only about four miles. A little south of the middle it is surmounted by a wedge-shaped comb of rock composed of a handsome variety of hornblendic trachyte, the crest of which was selected for Station XVII, and which attains an altitude of about 7,200 feet. The south end of the crest descends sharply to the broken continuation of the ridge, while to the northwest it more gently slopes, in places occupied by the sedimentaries, again by the narrowing volcanic mass, which latter finally disappears, the sedimentary beds lapping without break in their continuity over the ridge. A section across the ridge along a northeast and southwest line, perhaps half a mile north of Station XVII, commencing with the northeasternmost exposures, appearing in the gentle slopes that reach down into the basin-like valley of the East Fork of John Gray's Creek, just above the point where it begins its cañoned course in the basalt, is given below:

Section across Station XVII ridge.

1. Fine reddish-stained soil, appearing in the low upland terrace bordering the level creek bottom. It indicates subjacent shaly deposits.
2. Red shales and included sandstone layers, obscurely exposed in the grassy slopes.
3. Heavy bed of reddish-gray, even-bedded sandstone, weathering into flags; dip northerly.
4. Buff, reddish-tinted, thin-bedded, rather firm sandstone; sometimes a semi-quartzite with slickenside surfaces, including shaly gray sandstone, and underlaid by heavy-bedded, reddish buff sandstone, dipping 35° to 45°, east of north. The ledge forms a low hogback, several yards across, and which may be traced to a distance in the declivity. The upper ledge contains obscure vegetable impressions, fragments of limbs, and algæ-like markings. The surfaces of certain layers are undulated by large ripple-markings.
5. To the southwest of the last-mentioned bed, 60 or 70 yards, a low parallel comb of soft, thin-bedded, gray sandstone breaks the surface, the bed showing a thickness of 5 to 10 feet, and dipping 45° to 50°, N. 25° to 30° E.
6. Red shales, obscure exposure.
7. In the slope of the main ridge about 300 yards distant from bed 4, occurs an obscure outcrop of drab, brittle, earthy limestone, containing numerous small gasteropods, a few medium-sized lamellibranchs, and a minute fish-tooth.

8. Forty yards above the last, a similar hidden exposure of light gray limestone occurs, in which were found a few small gasteropods.

9. Drab argillo-calcareous indurated layers, apparently forming a heavy deposit in the crest of the ridge. This ledge has evidently undergone much metamorphism from contact with the igneous mass, by which it is so changed and intersected by a bewildering set of cleavage as quite to obliterate the bedding of the rock. However, at several places along the northeast side of the igneous dike it was possible to distinguish the planes of deposition from those of the superadded cleavage, showing an inclination N. N. E., at a steep angle; and at a point nearer the summit, the same ledges, here even more highly changed into an exceedingly brittle, slaty rock, were found to dip in the same direction at angles of 30° to 40°.

10. This is a beautiful variety of hornblendic trachyte, in which the dark needles of hornblende are very generally disseminated, only showing perceptible changes in the size of the crystals, which are embedded in a dark gray matrix. The ledge stands up in a dike-like mass, with a strike about E. 50° S. and W. 50° N., and apparently inclined seeply to the southwest. It forms the highest part of the crest of the ridge for the distance of about a mile, and several yards across. In the southwest face, under Station XVII, it presents a precipice in which the rock is seen to be much broken by irregular joint structure. Farther north, where the dike becomes less prominent, its outcrops is marked by *débris*, which strews the surface with fine gravel, imparting to the soil a rusty reddish color, markedly in contrast with the fine, light soil derived from the decomposition of the calcareo-argillaceous deposits of the adjacent slopes.

11. Drab, indurated argillo-calcareous deposits, interlaminated with light gray limestone layers containing great numbers of a small gasteropod. This horizon appears in the southwest slope of the crest, and is much metamorphosed on approaching the igneous dike.

12. Brown, partially fissile shales, with small concretions included in

13. Drab, indurated, argillo-calcareous deposits, with thin interlaminations of calcite.

14. Reddish gray sandstone, with slickenside surfaces. This ledge outcrops in the bed of the little valley a short distance below, or to the northwest of the line of the section, where it shows an inclination southward at an angle of 30°. Although a limited exposure, it is believed to be the equivalent of one of the beds in the northeast flank of the ridge, probably No. 4, which it closely resembles lithologically.

15. Obscure exposure of red shales.

16. Drab, indurated, fragmentary, argillo-calcareous deposits, with seams of calcite and gypsum, apparently forming a heavy bed, but imperfectly exposed in the northeast slope of low outlying ridge west of Station XVII.

17. Gray, fragmentary spar-seamed limestone, with numerous small undetermined gasteropods. A thick stratum, defining an abrupt break in the hill-side.

18. In the gentle slopes of the before-mentioned outlying hill west of Station XVII, a series of obscurely-exposed beds is met with, consisting of alternations of gray and drab fragmentary limestone and heavier beds of reddish and buff sandstones and softer deposits, which compose the bulk of this lesser ridge.

19. Basalt, filling the valley of the West Fork of John Day's Creek and lapping up on the sedimentaries all along the southwest flank of this low highland ridge.

The above section has a linear extent of about four miles between the forks of Gray's Creek. Although the deposits in the immediate southwest slope of Station XVII are somewhat obscure, and withal so altered by metamorphic action as render their examination difficult, yet their more favorable exposure in the opposite hill-side to the west affords satisfactory data for the determination of the relations of the sedimentaries to the volcanic phenomena with which they are here associated. The igneous mass protruding in the crest of the ridge seems to have been forced up nearly in a vertical direction, carrying the sedimentary beds up with it instead of fracturing them at once, so that at the extremities of the upthrust they were not rent apart. But at the point of greatest tension they were partially fractured, the igneous matter following the crevice thus produced, as a wedge-shaped mass, which subsequent erosion has bared, and thus revealed the origin of the little anticlinal fold, of which it forms as well the nucleus. The apparent identity of this eruptive rock with that prevalent in the Elk Mountains of Western Colorado, should also be mentioned, specimens from these remote regions showing slight if any difference in their mineral constitution.

The sedimentaries in Station XVII ridge, as before mentioned, may be traced to the northwest, where they reappear in the vicinity of Station XVI, in which latter quarter, however, the series belongs to the southwest side of the present uplift. From the latter station, looking across the broad valley of Willow Creek, beneath the greatly uplifted volcanics at the northern end of the Blackfoot Range, a considerable belt of reddish-tinged strata appears in the northeast flank of that range, outlying the Carboniferous in Blackfoot Peak. These deposits, as seen at a distance, present precisely the appearance of the strata exposed in the Willow Creek ridge above described; and continuing the north of west strike of the latter beds across the intervening plain where they are concealed from view by the basaltic flow, it would intersect the Blackfoot Range at the point where these deposits have their apparent counterpart in the foot-hills east of Blackfoot Peak. The trend of the eruptive mass in Station XVII is exactly in line with Mount Bainbridge (Station XXVIII), 16 miles to the southeastward, where mineralogically identical igneous eruptions are again met with, which will be noticed in a subsequent section of this chapter relating to the Caribou Range. The banded reddish and drab appearance of the outcrop of the sedimentary deposits of the present group of hills is repeated also in the foot-hills northwest of Mount Caribou and it seems very probable that the present uplift has intimate connection with the remarkable phenomena observed at that locality. These deposits may be described as variegated red and drab beds, the appearance they usually present in distant-viewed exposures. They form the low swells into which the southeast end of Station XVII ridge dies away, as also the similar terminus of the main Willow Creek ridge, as previously mentioned. In the undulating border hills to the northeast of the confluence of the forks of John Gray's Creek the same series of strata is also seen, where they are dominated by various levels of the upraised volcanics which rise up in abruptly terminated benches on the flank of the Caribou Range in that quarter. But everywhere in the lower depressions separating these low basin ridges, the sedimentary deposits of which they are largely composed are concealed beneath the basaltic flows, though their continuity scarcely admits of a doubt, however isolated their present manifestation.

Beyond the low basaltic plateau which envelops the southern end of the Willow Creek ridge, the surface again rises into a low ridge extending southeastward several miles into the adjacent district, and which

forms the watershed between the sources of John Gray's Creek and the Little Blackfoot to the west. This ridge has an extent of some eight miles in our district, attaining a pretty uniform altitude of 7,200 feet, its dominating summit rising about 1,000 feet above the level of John Day's Lake basin on the east. Near the southern line of the district it is suddenly contracted and broken down in a broad, deep sag, through which flows a pretty little tributary which rises in the low basaltic rim on the east flank of the ridge in the immediate vicinity of the gentle slopes surrounding John Gray's Lake. A well-beaten highway from the country to the southeast crosses the ridge at this pass, and following up the valley of Little Blackfoot it crosses over the low basaltic plateau at its head, and thence descends the west side of Willow Creek out into the Snake plains at Taylor's Bridge; a branch road crosses into the upper basin of the Blackfoot, and thence westerly to Fort Hall and Ross Fork Agency, where it again joins the great highway leading into Montana.

This ridge, which may be appropriately termed Gray's Lake ridge, south of the above-mentioned pass and lying within our limits, was found to present a simple monoclinal structure, the result of erosion, by which the east flank of an anticlinal fold was destroyed prior to the effusion of volcanic matter, which latter gently rises on either slope of the present ridge as heavy beds of more or less scoriaceous and compact dark basaltic lavas, which strongly resemble the material found in the summit of the Willow Creek ridge at Station XIV. The nucleus of the ridge is here seen to consist of the ordinary gray and drab Carboniferous limestones, interbedded with hard buff and reddish-buff sandstones or siliceous beds, and dipping southerly at an angle of about 30°. The ridge is here quite low, but it gradually rises to the southeast, where its bulk is composed of the same formation, the beds seeming to curve round the southern extremity of the ridge in a sharp quaquaversal, with outflanking foot-hills made up of red arenaceous deposits and sandstones and drab beds.

North of the pass these same deposits are seen in force in the northeast flank of the ridge, and after crossing to the southwest side, the same deposits also flank that side, where they incline southwestwardly, and probably here compose the entire bulk of the exposed strata in the main ridge. A mile or so southwest of the pass, at the crossing of the Little Blackfoot, in the extremity of a low upland spur which puts out into the valley at this point, the Carboniferous again appears, showing a thickness a hundred feet, more or less, of heavy bedded, gray, cherty and spar-seamed limestone, dipping 55°, S. 5° W. A few fossils were seen here, *Productus*, *Spirifer*, &c. The relation of the latter exposure to the ledges that form the crest of the ridge south of the pass was not clearly shown; but it is presumed that it belongs to the same uplift, although the trend of the strata has rather sharply changed more to an east-west course, if this inference prove correct.

The Little Blackfoot here occupies a wide trough-like valley, which heads in the low basaltic plateau of the Willow Creek divide a few miles to the northwest, and is bounded on the southwest by a similar narrow mountain ridge, the distance from crest to crest along our southern boundary being about four miles. The middle of the valley is occupied by a level tract, through which the little stream flows with many windings between low terraced borders which gently rise to the foot of the adjacent ridges. These border slopes in places conform to gently inclined basaltic benches, as is the case in the lake ridge to the south of the pass, where they were found extending quite to the crest in a low place in the ridge; but in the mid-valley the level surface is covered with

fine detrital material and soil which supports a fair growth of herbage, while in the hills a few dwarfed pines and groves of aspen are found.

The ridge defining the southwest side of the Little Blackfoot Valley originates in the low basaltic divide at the head of Willow Creek, and which separates it from the southern terminus of the Blackfoot Range, a few miles to the northwestward. This ridge has a course nearly parallel with Gray's Lake ridge, northwest and southeast, in which latter direction it is projected into the bend of the Blackfoot, a few miles south of the south line of the district. Like the previously described ridge, it is broken down near the middle, where it is crossed by a somewhat higher pass, with steeper approaches, just over our southern border, to the northwest of which it culminates in an irregular crest 7,000 to 7,600 feet altitude above the sea, or 600 to 1,200 feet above the plain. A section carried across the ridge at a point between the pass and one of the culminating summits a mile to the north, on which Station XXIX was located, is given below:

Section across Station XXIX ridge.

1. Dark bluish gray, spar-seamed limestone, with concentric siliceous nodules, passing upward into a very hard fragmentary siliceous rock. Occurs as a heavy ledge flagging the south-facing slope descending into the gap, and dips 35°, S. 25° E. The rock is complicated by joint structure and cleavage, the principal planes of which incline at an angle of 70°, N. 70° E.
2. Slope, unexposed.
3. Limestone, obscure exposure.
4. Heavy bed of buff siliceous rock.
5. Light bluish-gray spar-seamed limestone, forming a heavy bed the outcrop of which is traced in a line of low cliffs which rise into Station XXIX. A thickness of 50 feet is exposed in the mural face of the outcrop, in which atmospheric erosion has scooped miniature caverns and niches. Dip 45° to 50°, S. 65° W. The rock affords numbers of a large species of *Zaphrentis*, which was the only fossil a hurried search detected.
6. Space 200 yards across, showing gray cherty limestone and reddish-buff siliceous deposits. Dip 30° southwestward.
7. Bluish-gray, spar-seamed, cherty limestone, a heavy ledge, exposed 20 to 40 feet, and dipping 30°, S. 50° W. Contains a minute *Retzia*, *Hemipronites*, and crinoidal columns.
8. Slope, about 100 yards across; no rock exposures.
9. Limestone, similar to bed No. 7, appearing in crest of ridge about southwest of Station XXIX, over a space perhaps 300 yards across. Dip 50° to 65°, S. 50° W. Contains a small Zaphrentoid coral.
10. Grayish-blue limestone and buff siliceous deposits, forming a heavy deposit 300 to 400 yards across in the south flank of the ridge. Dip 55°, S. 45° W.
11. Intensely hard, brittle, hornstone-like rock, much fractured transversely, its outcrop presenting a dike-like appearance, exposed thickness 5 feet, and dipping S. 35° W. at an angle of 65°. This rock is precisely like a ledge observed in the southwest foot of Blackfoot Peak, with which it is believed to be identical.
12. Limestone, obscurely exposed in foot of steep slope, where it merges into the basaltic bench, over which the declivity descends thence into the upper basin of the Blackfoot in a series of more or less distinct low terraces.

The above section crosses the ridge nearly at right angles to its trend,

or in a general S. S.W. and N. N.E. direction. It will further have been observed that the strike of the ledges which compose the monoclinal crest of this part of the ridge trends round from a north of east to south of east direction in crossing from the northeast to the southwest side of the ridge, and exhibiting almost the exact counterpart of the condition of things found in the southeastern portion of the Day's Lake ridge. This structure is further indicated by the massing of a heavy series of superimposed red and drab deposits, which make up the bulk of the southern portion of the ridge. Above the pass, a short spur jutting from the northeast flank of the ridge and abruptly terminating in the valley, exhibits a heavy series of dark and chocolate-colored shales and rusty sandstone ledges, which incline at a steep angle toward the main ridge. The latter deposits apparently constitute a large portion of the southwestern extremity of the ridge, and they are supposed to pertain to the Jura-Trias series of the region.

The geological, as also the topographic, relations of this ridge are apparently intimate with the Blackfoot Range; yet this relationship is more a matter of inference than actual demonstration. In the basaltic plain which fills the interval the sedimentaries are, of course, concealed from view, and it may be that both of the latter ridges mentioned above are the result of locally-manifested disturbing causes by which the strata over narrow elliptical areas were bulged up into abrupt anticlinal folds, and probably faulted along parts of their course, as seems to be the case in the northeast side of Station XXIX fold. Yet, while isolated areas of local disturbance may, and doubtless do, exist, as, for example, the Station XVII uplift, this basin region as a whole is doubtless intimately related to the border areas where the most complicated foldings and faulting are prevalent; and the present isolation of the basin ridges, as also that of the more extensive border mountain belts, is due to subsequent erosion.

That portion of the upper basin of the Blackfoot lying within our territory forms a level plain, into which low benches of basalt extend from the basaltic plateaus and neighboring mountain ridges. The whole area is doubtless based upon the great lava flow; but in the mid-valley extensive tracts of level alluvial meadow-lands exist, through which the stream sluggishly winds between muddy reed- and grass-grown banks, resembling much a tide-water channel. In the adjacent acclivities of Station XXIX ridge and the low divide south of the Blackfoot Range considerable areas are covered by white calcareous tufa, deposits made by springs that issue from the limestone ridges.

John Gray's Creek opens into a wide, flat basin at its head, which is largely filled with meadow-lands, and toward the south boundary of the district it is occupied by a permanent body of shallow water, which is known as John Gray's Lake. These alluvial lands, consisting of a deep fine brown soil, are exceedingly fertile wherever water is carried upon them. Early in the season the influx of surface drainage greatly extends the ordinary and obscurely-defined limits of the lake, flooding extensive tracts on all sides. Indeed, the greater portion of the lake is merely a marsh, which is being gradually reclaimed by the deposition of fine sediments washed from the bordering uplands and the materials contributed by the decay of the dense growths of reeds, grasses, and moss which flourish in the oozy soil.

In the midst of the lake rises a low island, perhaps a hundred feet high, which shows in the summit, near the southern end, a rather prominent ledge of rusty-weathered rock, dipping, at a gentle angle of inclination, westerly or southwest, in which direction the elevation also declines.

The rock may possibly be volcanic; but it is rather believed to belong to the sandstone series which appears in the low hills to the southeast of the lake, where they dip gently southwesterly, and pass into the adjacent district. The latter hills and their imperfectly-exposed stratigraphy will be briefly noticed in connection with the section across the Caribou Range, through Station XXVIII (Mount Caribou), in the following section of this chapter.

THE CARIBOU RANGE.

The highland belt lying between the Willow Creek Basin and the lower valley of the Snake and its southern continuation, the Salt River Valley, to which the general designation Caribou Range has been given, comprises a rather regular area which extends from a point south of our southern boundary northwesterly a distance of 40 to 45 miles within our district, with an average width of about 14 miles. South of McCoy Creek and the Caribou mining district, where it attains the latter breadth, it gradually narrows, and where its crest shows a series of undulating, wooded hills. To the north, again, it expands to 18 miles across, between Fall Creek and the next considerable stream to the south, Pyramid Creek; and thence northward it is continued in a lower and narrower ridge, which finally expands into a plateau overlooking the grassy upland on the borders of the Snake plain. The culminating points along the main crest, which lies well to the east of the geographical axis of the range, attain altitudes ranging from 8,000 to 9,600 feet above sea-level; but on the southwestern border in the southern portion of the range, the somewhat isolated mountain mass in the Caribou mining district reaches an altitude of 9,800 feet, and which dominates the whole southwestern section of this district. This peak, which was variously known by the names Caribou Mountain and Mount Pisgah, was rechristened by Mr. Bechler Mount Bainbridge, in honor of Captain Bainbridge, commandant at Fort Hall, from whom and Lieut. Joseph Hall, of the same post, our party met with courteous and generous reception, which contributed materially towards furthering the objects of our visit.

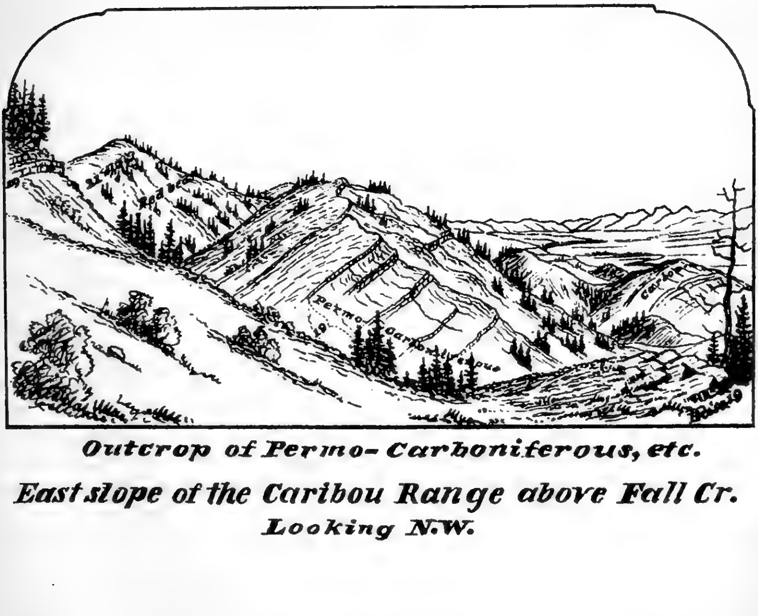
A marked peculiarity of this range is the relation of the main or topographic crest to the hydrographic divide or watershed. As above remarked, the culminating crest lies to the east of the central longer axis, which is thrown into a devious course by the drainage, with an intricate system of supporting ridges due solely to erosion, and rugged intermountain spurs, which were determined by the stratigraphic structure of the range. This belt is boldly severed by the drainage channels, across which their beds lie in deep, rugged gorges, abounding in wild and picturesque scenery, their sources originating in beautiful little mountain basins situate within the southwestern half of the range. The watershed, which separates this main drainage from that flowing into the Willow Creek basin, is alike irregular in its course and elevation, though uniformly lower than the topographic crest, except a limited portion of the divide, only a few miles in extent, formed by the dominating peak, Mount Bainbridge. But to the north of the latter mountain, as also to the south, the watershed is crowded nearly over to the southwest verge of the range, the sources of Tin-cup and McCoy Creeks rising within three or four miles of the basin plain of Day's Lake. Near the middle, and between the latter creek and Fall Creek, the East Fork of John Day's Creek heads well up in the range at a point from which radiates the drainage of the three principal water-courses which flow directly into the Snake, viz, McCoy, Pyramid, and Fall Creeks. To the north, two

PLATE XVII.

Snake Plains. Sta. XX.

Caribou Range. (Looking N.W.)

a. Fall Cr. Cañon. b, b'. Inverted Jurassic.
c. Laramie(?) and Post-Jura. d. Volcanic.



Outcrop of Permo-Carboniferous, etc.

East slope of the Caribou Range above Fall Cr.
Looking N.W.

considerable tributaries which rise in the main crest gain the main Willow Creek on its right bank, while Grouse Creek and several smaller streams rise in the opposite side of the crest and flow into the Snake.

The bulk of the range is fashioned out of sedimentary formations, and these belong chiefly to the Mesozoic and the earlier epoch of the Cenozoic age. Along the middle portion of the northeastern border, rocks of Palæozoic age are encountered, which, like the later-formed strata, have been tilted and folded in a remarkable manner. The disturbing forces which resulted in the plication of these sedimentary deposits acted pretty uniformly along northwesterly and southeasterly lines, with, however, local deviations in both the direction and intensity of their manifestation, to which is attributable the variety of the phenomena here observed. These may be briefly summed up as sharp anticlinal folds, and corresponding synclinal troughs, great flexures marked on the one hand by the vertical and even overturned position of the displaced beds, while on the other they appear to have formed broad-topped folds with gentler inclination on the opposite border; and it seems almost certain that, with these more extraordinary displacements, are associated other attendant phenomena, such as the faulting of the strata, by which formations of remote periods of origin are brought into immediate juxtaposition in the opposite walls of the severed beds. Besides the deposits of sedimentary origin, there are limited areas in the higher mountain region where rocks of volcanic origin are met with. These are supposed to represent two distinct epochs of volcanic activity, the one and earlier occurring as dike-like and intruded masses, the effusion of which not only fractured the sedimentaries vertically, but forced apart the strata between which they are intruded as great wedges. The later effusion, consisting of trachytic and other lavas, appear simply to have overflowed pre-existing elevations, but which have since been subjected to extensive erosion, from which the unconformably superimposed volcanics have suffered almost to annihilation, only mere remnants remaining to show their probable former extent. These latter volcanic flows pitch off towards the basin depressions, in the borders of which they are succeeded by the still later basaltic lavas which fill the basin areas to the north and west. The local aspects of the geological components of the range will be noticed more at length in the following pages, devoted to the detail account of the observations prosecuted in this quarter. These will be taken up in nearly the order of their original observance.

Our route penetrated the range at its widest part, following up the East Fork of John Gray's Creek, or near the middle in its southwest border. This stream, whose sources are gathered in a little hilly mountain basin, cuts a short cañon across a rather high outlying ridge, which here forms the foot-hills along the southwest flank of the range. This ridge rises rather abruptly from the basin plain, 800 to 1,400 feet in height, its direction W. N. W. and E. S. E. It terminates abruptly on Mosquito Creek five miles west of the debouchure of East Fork, to the east of which it merges into the watershed at the head of McCoy Creek, where it reaches its greatest elevation. This is the appearance as seen from the basin plain; but it really forms part of a block of the western flank of the range, from which erosion of the drainage channels has almost dissevered it, a series of extremely rugged saddles and combs alone maintaining its connection with the parent mass. Like so many of the streams in this range the East Fork divides in its mountain basin, the two branches uniting from opposite directions, which are found to coincide with the general direction of the strike of the rocks in which their beds are eroded. So, also, the courses of the principal lateral tribu-

taries are generally determined by the same causes. In the present instance, the side affluents of the streams which rise in this block have molded it into a series of parallel spurs united by a median ridge to the watershed, and this in turn by devious and exceedingly variable ridges hitching on to the main heights which lie to the east of the drainage divide. From any of the high points in the range, the above-described features stand out in bold relief.

Passing from the basin-plain to Station XVIII, which occupies the crest of a highish ridge some four miles to the northeast, the first rock exposures encountered are low in the foot of the outer ridge, where an obscure ledge of (1) reddish gray sandstone forms a low bench peering above the gravelly second-bottom which here borders the East Fork of Gray's Creek. Higher in the slope the surface is covered with the *débris* of (2) fine drab indurated argillo-calcareous deposits and drab-gray limestone, above which appears (3) laminated grayish buff sandstone associated with red arenaceous shales and sandstone layers, dipping southerly or southwesterly. A little higher in the slope, and in the crest of a low ridge west of the debouchure of the East Fork, similar (4) sandstones interbedded with deep and pale-red sandy shales, making up a heavy deposit, show moderate inclination to the northeastward, indicating a low anticlinal fold. The foregoing exposures are, however, very obscure, as is the case with many yet to be mentioned in the easterly portion of the section here referred to; so that it is only now and then a ledge affords satisfactory observation on their position as determined by the direction of strike and inclination of the strata. Crossing up through the narrow gap, the way lies over a series of deposits, which to the westward are seen outcropping in successive bands, one above the other, in the steeper and higher portion of the ridge, and also appear, though apparently less distinctly marked, in the more rounded ridge east of the gap. These deposits were found to consist of (5) sandstone and red sandy shales, dipping steeply northward, at one point at an angle of 70°, standing up in the surface like narrow dikes or combs, the harder ledges breaking into rhombic blocks. In the opposite southeast side of the narrows, the shales are seen in steep banks of a bright red color, while everywhere they give to the soil its peculiar tint. Entering here the little mountain basin, its floor is over deposits similar to those last mentioned, or (6) dull chocolate-red shaly sandstone and reddish shales, which, however, dip southerly at a much less steep angle of inclination. The little basin is hemmed in by broken hills covered with shrubs, and patches of conifers in the shaded deeper ravines and northern slopes. The little streams are obstructed with beaver-dams and their narrow flats, a jungle of willow and low growth. It is headed off by the watershed, here an extremely broken ridge 1,600 to 2,000 feet in height, with quite considerable tracts of pine and fir. Just to the southwest lies the parallel ridge of Station XVIII, in ascending which the following observations were made: In the foot of the southwest slope, a heavy deposit consisting of (7) ledges of reddish-gray sandstone interbedded with red shales with flakes of selenite and calcite, occurs, dipping southerly or west of south, at an angle of 35°. The much-encumbered slope shows only imperfect exposures of (8) bluish limestone *débris*, (9) red gritty shales, and (10) drab argillo-calcareous deposits, which latter at one point appear in the crest of the ridge, where their decomposition has produced a soil peculiar to these shaly beds. The crest of the ridge, which lies a little to the north and south of the line of strike of the strata, shows in its southeast portion heavy ledges of (11) rusty gray and deep red shaly sandstone, showing slickenside surfaces and false

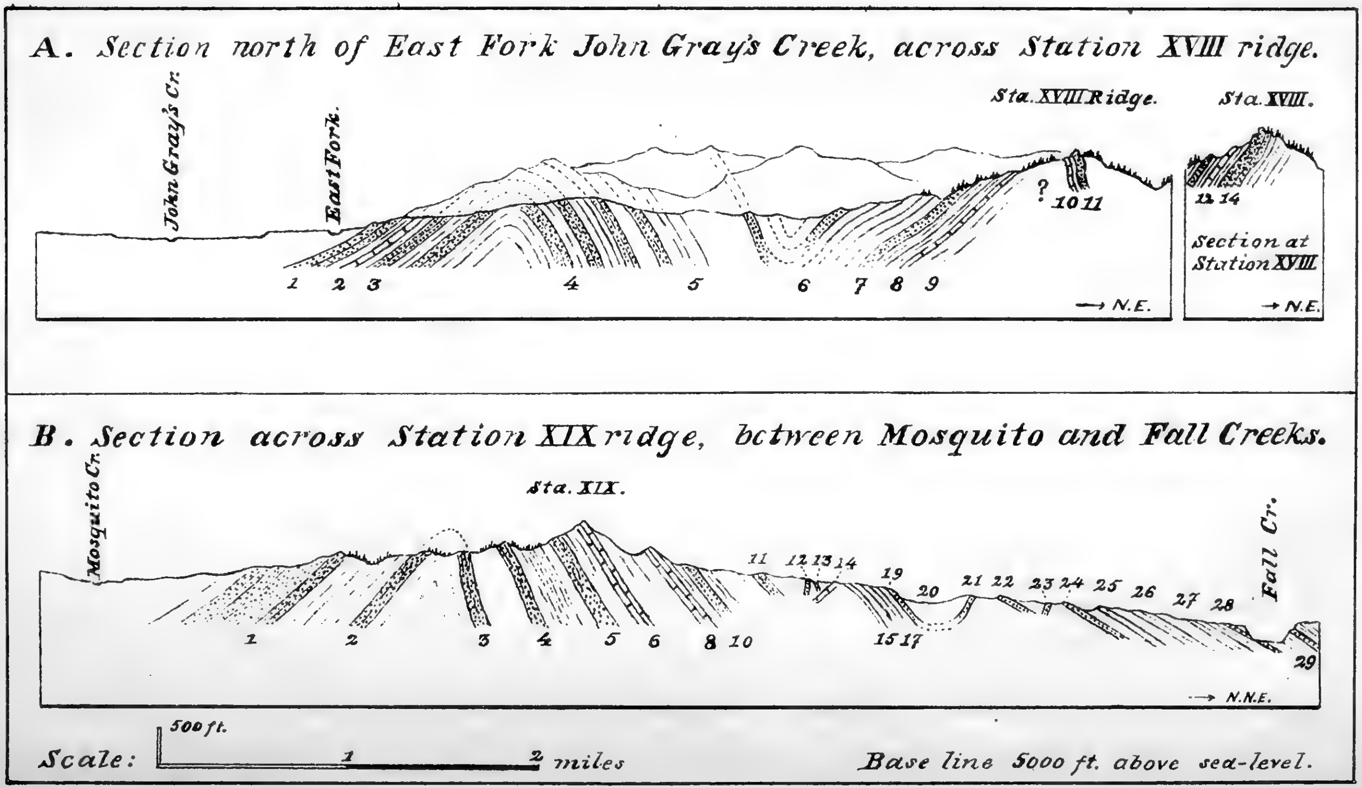
bedding, associated with red shales, which stand in various positions, or dipping from vertical at one point 65°, N. 45° E., changing in a short distance to the opposite direction at a steeper inclination. This continues to be the character of the ridge to its northwest extremity, where it is broken down in a low saddle at the head of Mosquito Gulch, which connects it with the highlands to the northwest on which Station XIX was located, about three miles distant from Station XVIII. At the latter point the ridge shows an interesting section. The last-mentioned sandstone horizon, forming a brown weathered ledge with red shales, outcrops in the south declivity a hundred yards from the summit, and dips steeply southward. A little higher in the slope, a heavy ledge of (12) bluish-drab, spar-seamed limestone forms a break in the steep descent, the dip ranging from 45° to 60°, S. 30° to 40° W. It contains numbers of a small Gastreopod and very imperfect Lamellibranchiates, and vertebrate remains. Of the latter, only a few indeterminable fragments of bone, and a single specimen of a vertebra, rewarded a careful search. The Gasteropods are undistinguishable from a form occurring elsewhere in post-Jurassic deposits, and the Lamellibranch may prove to belong to the genus *Unio*. Professor Cope's determination of the crocodilian affinities of the vertebra also bears strong, though not conclusive, evidence in favor of the transitional or early Cenozoic age of these deposits. The limestone is immediately succeeded by (13) indurated brownish ferruginous deposits, also containing obscure fossils, apparently a Lamellibranchiate shell. The crest of the ridge immediately above the latter exposure is formed by a heavy bed of (14) hard, grayish blue, rusty weathered, spar-seamed, brecciated sandstone, with slickenside surfaces, and much broken up. It dips 75°, S. 30° W., in places vertical.

From the foregoing observations it is apparent that we at the outset of our examinations along the outlying southwestern border of the range encounter evidences of the extraordinary character of the disturbances which constitute so prominent a feature in its dynamical geology. In the short space gone over there are two sharp folds, that on the crest of which Station XVIII is located, pitching steeply to the northeastward, and in places thrown beyond the vertical, reversing the order of superposition of the strata involved in the overturn. The northeast face of Station XVIII ridge falls rapidly into the gulch of the main northwest branch of the East Fork, over a declivity covered with dense thickets and coniferous forests. Beyond lies a far more broken and higher mountain region, culminating in Station XXV, 10 miles to the northeast, which overlooks the lower valley of the Snake between Pyramid and Fall Creeks. To the north, this ridge attaches to the water-shed at Station XIX, northwest of which it sinks into a broad depression some six miles across and 800 feet in depth, opening a low pass from Willow Creek, via Fall Creek, across to the lower valley of the Snake. This pass is very like the depression at the head of McCoy Creek, though the cañoned course of Fall Creek affords a less practicable route for a highway than the more open valley of the former stream. The view looking south and southeast embraces the basin ridges west of Gray's Lake, and the crater-like northwestern face of Mount Caribou, and far in the distance, in the direction of the Wind River Mountains, a line of snowy peaks stretches across the horizon.

Approaching Station XIX from the valley of Willow Creek, a section is crossed which extends our knowledge of the component strata in a belt still more northerly than that just noticed. The way leads in a general northerly course a distance of about six miles, the southern third or

more belonging to the Willow Creek drainage, the remainder passing over the gentler slopes descending into the mountain basin of Fall Creek. In the gentle ascent which rises into the first ridge north of Mosquito Creek, a heavy series of (1) reddish-buff or gray sandstone associated with chocolate-red shales, rarely blue shales as in the foot of the bluff on the south side of the stream, appears, dipping at an angle of about 45°, southerly. These deposits are here largely developed, the extent of the outcrops being probably not far from three-quarters of a mile across. From this first sandstone crest the way descends, passing along the broken saddle-crest to a corresponding and little higher ridge, perhaps a mile distant. In the sag (2) obscure sandstone exposures first appear, and beyond (3) another sandstone ledge outcrops in a vertical position, inclosed in deposits of red shales. The second ridge is capped by (4) a similar ledge of sandstone, dipping northward, followed in that direction by red shales and sandstones interbedded, which appear in the saddle connecting this with the water-shed ridge on which Station XIX was made. In the southerly slope of the latter ridge alternations of (5) gray, thin-bedded, spar-seamed sandstone and red shales are met with, but in the crest these are replaced by (6) a thick bed of dark gray and light drab, fragmentary limestone, dipping N. 45° E. at an angle of 60°. The only fossil observed in this bed was a small indistinct Gasteropod apparently identical with a form prevalent in the Laramie of this region. In the northeast face of Station XIX ridge, a (7) heavy deposit of red shales follows, and is in turn overlaid by (8) a heavy bed of gray limestone, crowded with a form of small Gasteropod in a state of silicification, but so badly preserved as not to be determinable with certainty. This ledge is so complicated by cleavage and joint planes as greatly to obscure the true bedding, which, however, was found to incline about northeast at an angle of 50°. This is immediately succeeded by (9) red shales, including gray brown-stained sandstone, more or less exposed in the foot of the steeper declivity, from which the descent to Fall Creek is over a broad grassy terrace slope curiously eroded by the shallow lateral draws of the deeper drainage channels, which divide this sloping bench into so many regular compartments. Owing probably to the nature of the deposits is due both the long and comparatively gentle slope descending to Fall Creek and the hidden or limited exposures met with along this part of the line of the section. But such as they are, and to give the facts as full record as possible, they are noted down in detail, their relative position being approximately indicated in one of the accompanying diagrams, where it will be seen that the strata referred to below occur over a space above two miles across, in a direction at right angles to their strike. (10) Gray, brown-stained, coarse-grained, laminated sandstone, dip 65°, N. 60° E. This bed is broken up by cleavage and joint structure, the planes of which incline to the southwest at angles of 20° to 35°, and, but for the laminæ which portions of the rock still retain, might be mistaken for the bedding. A space several hundred yards across follows, in which only a single rock exposure occurs, near the middle, showing (11) a similar even-bedded rusty-gray sandstone. Then follows a dike-like exposure of (12) light gray, very hard sandstone, much broken up, and tilted on end, though at certain points along the line of its exposure it is slightly inclined from the vertical southward; again, an obscurely laminated layer of the same bed dips at an angle of 60°, N. 40° E. (13) Red shales with calcite, also small abraded or nodular limestone pebbles in surface. (14) Much jointed and fractured hard, gray, spar-seamed sandstone, with slickenside surfaces. The rock shows false-bedded layers, but the prevalent lamination in the dark-brown stained portions indicates an

PLATE XVIII.


A. Section north of East Fork John Gray's Creek, across Station XVIII ridge.
John Gray's Cr.
East Fork.
Sta. XVIII Ridge.
Sta. XVIII.
1 2 3 4 5 6 7 8 9
? 10 11
12 14
Section at Station XVIII
→ N.E.
→ N.E.
B. Section across Station XIX ridge, between Mosquito and Fall Creeks.
Mosquito Cr.
Sta. XIX.
Fall Cr.
1 2 3 4 5 6 8 10
11 12 13 14 19 20 21 22 23 24 25 26 27 28
15 17
29
→ N.N.E.
Scale: 500 ft. 1 2 miles
Base line 5000 ft. above sea-level.

inclination S. 55° W., at an angle of 47°. (15) Gray sandstone, breaking into cubical blocks, laminæ showing a dip of 35°, N. 35° E°. (16) Gray, thin-bedded or shaly laminated sandstone, rusty buff weathered, forming a heavy deposit 50 to 80 yards across its outcrop, and dipping 32°, N. 40° E. (17) Gray-buff, thin-bedded, laminated sandstone, exposure 20 yards across, dip 35°, N. 40° E. (18) Gray laminated sandstone, exposure 15 yards across, dip 30° to 40°, N. 5° W. to N. 45° E. (19) Dark gray, thin-bedded, spar-seamed sandstone, 20 yards across exposure, dip same as last. North of the last exposure a shallow sag, several hundred yards across, intervenes between the higher and lower levels of the bench, in which occur obscure exposures of (20) reddish shales with calcite and selenite. In the upper edge of the lower platform appears (21) a narrow ledge of soft, thin-bedded, spar-seamed, gray sandstone, 5 yards across its exposed edges, dip 60° to 70°, S. 50° W. (22) Gray, thin-bedded sandstone, very obscure exposure, at one point apparently dipping northeastward at an angle of 30°, the broken outcrop 10 yards across. (23) Coarse gray sandstone, associated with a 2-foot layer of bricciated or conglomeritic limestone composed of small fragments of drab limestone, dipping at angle of 75°, S. 50° W. This bed is included in reddish shales with calcite and gray sandstone. (24) Compact laminated gray sandstone, 5 yards across the exposure, dip 30°, N. 45° E. (25) Gray, fragmentary, spar-seamed sandstone, 2 feet, underlaid by a thin band of sandstone associated with red and drab shales, dip 25°, N. 35° E. (26) Gray limestone *débris* in low swell, associated with reddish shales containing calcite, and nodules or pebbles of reddish stained and drab limestone in intermediate space. Thence to the brink of the bench the surface reveals only obscure exposures of (27) reddish shales with perhaps intercalated soft gray sandstone. In the face of the terrace-bluff on the west side of the Fall Creek intervale, a considerable thickness of (28) red and blue shales, with a heavy-bedded layer of gray sandstone, was seen, the beds dipping at a moderate angle northeastward, and reappearing, or a part of the same series, in the opposite bluff.

In the last series of strata mentioned above, beds 11 to 28, inclusive, conclusive evidence is furnished on their disturbed condition. But the repetition of similar strata, together with their generally indifferent exposure, did not allow the tracing out of actual identity of any stratum at different points, except along the outcrop of the same ledge. Hence, it is impossible to construct such a section as shall represent actual stratigraphic continuity, though we may endeavor to represent, approximately, the position of the strata in their folded condition, the inferences for which disposition may be consulted in the diagram illustration of the above section. From this it is apparent that, within the space between Station XIX ridge and Fall Creek, these deposits have been thrown up in two quite sharp folds; and it is further probable that they succeed the strata of the latter locality conformably, the folds to the north suddenly showing more gentle dips, which might, indeed, almost suggest the interposition of nonconfomity in explanation of their relative position. The southernmost series of strata included under No. 1 of the above section apparently belongs to the similar series occurring to the west of Station XVIII ridge; and it seems equally probable that the fold, the axis of which is represented by No. 3, also corresponds to the axis of the fold to which the beds of the latter locality belong. Hence, the limestones No. 6 and No. 8 evidently occur at a much higher horizon than that affording the vertebrate fossils at Station XVIII, from which the Laramie age of the associated strata at the latter locality is inferred. But besides these, whose fossils unfortunately do not admit of

present determination, there is found in the northern third of the present section a somewhat different series of arenaceous deposits, mainly characterized by their prevailing grayer color and generally looser texture, and the greater preponderance of shaly deposits with which they are interbedded. At a locality a mile or so above the upper entrance to Fall Creek Cañon these deposits appear in the low bluffs of an arroya on the southwest side of the valley, where they exhibit a vertical thickness of perhaps 75 feet. They consist of (*a*) a stratum of brown-gray, jointed, spar-seamed sandstone, which outcrops in the bed of the gully; (*b*) blue and chocolate-red shales, 50 to 75 feet; (*c*) gray, spar-seamed, coarse-grained, sometimes conglomeritic, sandstone, in places thin-bedded, with oblique laminæ, alternating with hard and soft layers, of which a thickness of 10 to 12 feet is exposed, dipping at angles of 25° to 33°, N. to N. 15° E. This locality derives much interest from the occurrence in the upper sandstone (*c*) of the remains of a flora, which is represented by several varieties of as many dicotyledonous generic types. These were submitted to Professor Lesquereux, and in a note kindly announcing the result of his examination, the most perfectly preserved form is referred to *Auralia.* The specific affinities of this fossil are thought to be intimate with Dakota Group forms; but while Professor Lesquereux takes due cognizance of this fact, he observes the probable later origin of this flora, and the strata in which it occurs, belonging to an epoch represented by the transitional or Laramie Group, which ushered in the dawn of the Cenozoic time. The conclusion here indicated corresponds with the discoveries reported by the survey in the country to the south, where vegetable remains of the same general facies, here referred to, are met with in otherwise well-determined Laramie horizons.

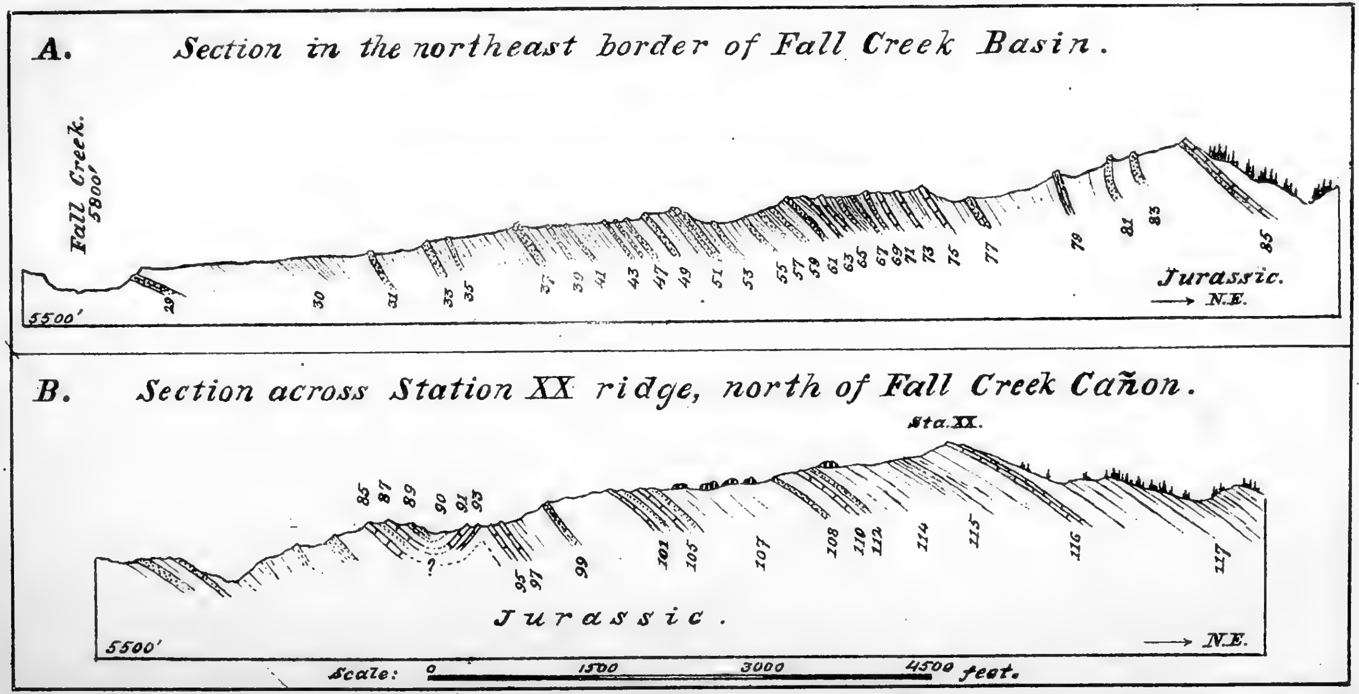
In the opposite and steeper acclivity on the northeast side of Fall Creek basin, a splendid series of strata in direct continuation of the foregoing section is pretty well exposed, affording the data for the following detail stratigraphic section. This side of the valley is bounded by a rather regular ridge, which may be traced many miles to the southeast, where it culminates in a high crest at the head of Pyramid Creek, 8,800 feet in altitude. It reappears in the heights south of McCoy Creek, between Station XXVII and Mount Caribou (Station XXVIII), while to the northwest it forms the portal of the upper entrance to Fall Creek Cañon, and finally dies out some distance beyond Station XX, where its altitude is 7,400 to 8,000 feet above sea-level. As seen from Station XIX, the southwest slope of this ridge, descending into the mountain-basin, is painted in bright bands of color, light drab and pale red, and is for the most part quite free from trees. The upper portion of the slope is broken into three, more or less, gradually steepening tilted benches, from the foot of which a wide apron sweeps down into the valley, where it terminates in bluffs 100 to 200 feet in height, which here hem in the intervale-margined trout-stream. It is in the latter bluff-face the lowest or first exposures in this northeast border ridge are met with, and these belong to the series last mentioned in connection with the preceding section in the opposite slope of the valley. The section is as follows:

Section in the northeast border of Fall Creek basin.

29. *a*, red and blue shales; *b*, gray, shaly sandstone, 5 feet exposed, underlaid by hard, indurated, ferruginous, gritty bed, dip N. N. E.; *c*, red and blue shales.

30. Long grassy slope, in which obscure exposures of red and drab shales appear.

PLATE XIX.


A. Section in the northeast border of Fall Creek Basin.
Fall Creek.
5800'
5500'
29
30
31
33
35
37
39
41
43
47
49
51
53
55
57
59
61
63
65
67
69
71
73
75
77
79
81
83
85
Jurassic.
N.E.
B. Section across Station XX ridge, north of Fall Creek Cañon.
Sta. XX.
85
87
89
90
91
93
?
95
97
99
101
105
107
108
110
112
114
115
116
117
Jurassic.
5500'
N.E.
Scale: 0 1500 3000 4500 feet.

31. Gray, thin-bedded sandstone, 10 to 15 feet exposed; dip 50° to 60°, N. 35° E.
32. Reddish shales, obscure exposure 100 yards across.
33. Gray, shaly, obliquely laminated, spar-seamed sandstone, forming a marked ledge in first sharp break in the slope, exposed 10 feet; dip 65°, N. 35° E. This resembles the plant-bearing ledge in the opposite side of the valley, but it is doubtless much higher.
34. *Débris*-covered slope, 25 yards across.
35. Gray sandstone, 2 feet exposed.
36. Reddish shales and *débris* in slope 100 yards across.
37. Hard, brittle, gray and buff sandstone, prominent ledge, 10 to 15 feet exposed; dip 50° to 60° N. 30° E.
38. *Débris*-covered slope, 55 yards.
39. Hard, brittle, fragmentary brown sandstone, 4 feet exposed; dip 48°, N. 35° E.
40. *Débris*-covered slope, 30 yards.
41. Greenish-gray, brittle, fine-grained arenaceous rock, obscure exposure.
42. Red shales, 55 yards.
43. Thin-bedded, gray sandstone, 4 feet, underlaid by thin layers of fine-grained sandstone; dip 45°, N. 30° E.
44. Red shales and *debris*, 20 yards.
45. Gray sandstone, like 43.
46. *Débris*-covered slope, 8 yards.
47. Gray sandstone, like preceding.
48. Red shales with calcite and *débris*, 35 yards.
49. Hard, brittle, rusty-weathered, gray sandstone, 4 feet exposed, associated with gray and dark gray, laminated, fragmentary sandstone, with comminuted vegetable remains; dip 45°, N. 35° E.
50. *Debris*-covered slope, 35 yards.
51. Two ledges of sandstone, separated by *debris*-covered space, 15 feet exposed. The upper ledge is a gray, brown-weathered, shaly sandstone locally; dip 50°, N. 40° E.
52. Steep slope into depression, with obscure exposures of brown sandstone, 70 yards.
53. Dark brown, drab-mottled sandstone, 3 feet exposed; dip 60°, N. 40° E.
54. Drab and red shales, with thin layers of gray sandstone, 45 yards.
55. Gray, red, and brown-weathered, thin-bedded sandstone, 3 feet exposed; dip 65°, N. 35° E.
56. Red and blue shales, 27 yards.
57. Thin-bedded, hard, blue sandstone.
58. Red shales, 15 yards.
59. Gray, thin-bedded sandstone, 2½ feet exposed; dip 55°, N. 40° E.
60. Drab and chocolate-colored shales, 35 yards.
61. Gray, spar-seamed, brittle limestone, with obscure traces of fossils, Lamellibranchiates, 2 feet exposed; dip 40°, N. 40° E.
62. Drab shales, 25 yards.
63. Drab-gray, fine-grained, fragmentary limestone, thin bed.
64. Drab shales, 45 yards.
65. Dark gray, coarse-textured, and drab, fine-grained limestsone, 4 feet exposed; dip 60°, N. 40° E.
66. Bluish and red shales, including a thin layer of sandstone, 60 yards.
67. Gray sandstone, 4 feet exposed.
68. Reddish-brown indurated shales, 15 yards.

69. Gray, fine-grained sandstone; dip 65°, N. 30° E.
70. *Débris*-covered space, 12 yards.
71. Dark drab brittle limestone, 2 feet exposed.
72. Drab shales and *débris*, 30 yards.
73. Gray limestone, 3 feet exposed.
74. Drab shales, 40 yards.
75. Drab-gray, brittle limestone, 30 feet exposed.
76. Abrupt slope into depression, covered with *débris*, 100 yards.
77. Sandstone ledge, obscure.
78. *Débris*-covered slope, 125 yards.
79. Drab and gray, fine-grained, fragmentary limestone, a heavy ledge, dipping 70°, N. 30° E.
80. Reddish shales, 80 to 90 yards.
81. Gray, brown-stained, laminated sandstone, 10 feet, or more, exposed in rugged dike-like ledge; strike E. 33° S., dip wavering from vertical to the north or south, at an angle of 85°.
82. Red shales, 30 yards.
83. Sandstone, like bed 81, but less well exposed, standing in vertical ledges, or dipping steeply to the north or south, locally.
84. Slope over red shales, and covered with gray sandstone and limestone *débris*, 80 yards.
85. Dark gray, brown-weathered, fragmentary limestone, 10 to 15 feet exposed, passing below into greenish, gritty, calcareous layers; dip 40° to 45°, N. 18° E. The upper layers are charged with the broken remains of a small *Ostrea*, like *O. strigulecula*, an undetermined Lamellibranch, and a fragment of a shell doubtfully referred to *Rhynchonella*.

The last-described limestone ledge forms the crest of the ridge bounding the northeast side of Fall Creek Basin, and as the ridge rises to the southeast, the limestone is carried up to higher elevations, culminating in a rugged mountain cluster 8,400 feet actual altitude, and 1,000 to 1,200 feet higher than the crest at the point crossed by the section a couple of miles south of Fall Creek Cañon. The ridge breaks down into a deep parallel gulch on the northeast, beyond which a series of similar ridges and ravines occupies the interval extending to the lower valley of the Snake, 8 miles distant. In the latter quarter the broken surface is covered with shrubs and conifers, the latter especially flourishing in the steep northerly slopes and filling the gulch beyond our ridge with a dense forest. The south-facing slope, however, is grassy with a sparce growth of scrubby cedars. To the northwest the highlands are much cut up by deep, narrow ravines, radiating from the watershed north of Station XX, which also forms the culminating crest in the northern part of the range. To the westward lies the depression, opening into the Middle Fork of Willow Creek, a region of low undulating surface contours, surmounted by the peculiar inclined benches which mark the presence of the gently upraised volcanics. The latter appear in the north slope of the depression, resting on the divide, and thence sweep round north of west, continuous with the great flows which fill the Willow Creek Basin.

Ascending to Station XX, opportunity was had for carrying our section still farther into the heart of the range, where a variety of geological phenomena of unusual interest were noted. The way led up a gulch tributary to Fall Creek, and gaining the end of the spur rising north into the summit on which the station was established, the first ledges encountered cannot lie far north of, and consequently above (?), the uppermost stratum shown in the preceding section. South of this

point, in the abrupt slopes terminating the spur, sandstones and drab limestone ledges are seen, probably the equivalents of the strata occurring below the summit in the ridge of the previous section. The section here exposed, along a north-south line, commencing one and a quarter miles south of Station XX, is as follows:

Section through Station XX.

85. Heavy ledge of grayish, rusty-weathered, fragmentary limestone; dip northward. This bed may be the same as that in crest of ridge southeast of Fall Creek Cañon, shown under the same number in last preceding section.

86. Sag, with bluish-gray, soft, shaly, gritty deposits above, 50 yards across.

87. Dark gray, thin-bedded, fragmentary limestone, exposed 8 feet. Dip 35° to 45°, N. 25° E. Contains segments of the column of *Pentacrinus*, and a small Echinoid (?) spine.

88. Slight depression covered with *débris*, 50 to 60 yards.

89. Gray sandstone, in part thin-bedded, obscure outcrop in low crest.

90. Deep sag, in the bottom and north slope of which appear red shales, 120 yards, more or less.

91. Obscurely exposed ledge of bluish-gray, spar-seamed limestone, 5 feet, apparently dipping S. 40° W., at an angle of 48°. *Pentacrinus*, and other indeterminate fossils.

92. Drab, indurated, arenaceous shales, 30 yards.

93. Limestone, similar to bed 91, 5 feet.

94. *Débris*-covered slope, 30 yards.

95. Dark blue-gray, brittle, spar-seamed limestone, 10 to 20 feet across the outcrop; dip 55°, N. 35° E. Contains *Pentacrinus.*

96. Light drab, indurated shales, 30 yards.

97. Limestone, like preceding bed, 10 to 20 feet across the exposure.

98. Broad, shallow sag, with red shales, 100 yards.

99. Brownish-red sandstone, obscure exposure.

100. *Débris*-covered slope, with shaly, gray sandstone above, 150 yards.

101. Brown, hard, thin-bedded, gritty limestone, 5 feet exposed; dip 35°, N. 60 E. Contains a small Ostrea, *O. strigulecula*, White, and *Pentacrinus.*

102. Gray indurated shales, 15 yards.

103. Brown sandstone, obscure exposure.

104. *Débris*-covered, shallow sag, 35 yards.

105. Darkish-gray limestone, imperfect exposure of a heavy ledge, associated with greenish-gray sandstone, 40 feet across outcrop; dip 35°, N. 75° E. Obscure fossils.

106. Grayish sandstone, seen in low, rocky ridge 40 feet across; dip 44°, N. 55° E.

107. *Débris*-covered surface, upon which rest large, abraded bowlder-like masses of dark, rusty vesicular lava with obsidian, 300 yards. This volcanic-covered bench is, perhaps, 400 feet lower than the summit.

108. Heavy bed gray, thin-bedded sandstone, 20 to 25 feet; dip 25° to 30°, N. 35° E.

109. *Débris*-covered slope, 60 yards.

110. Dirty gray, fragmentary limestone, obscure exposure. Contains *Belemnites densus ? Ostrea strigulecula.*

111. Slope, covered with *débris* and fragments of obsidian, 10 yards.

112. Very hard, dark blue, chocolate-stained, spar-seamed sandstone, 5 feet exposed; dip 35°, N. 40° E.

113. Low ridge, covered with the rusty brown vesicular obsidian lava, also here occurring in abraded masses, 60 yards.

114. Slope, showing red shales and obsidian fragments, 125 yards.

115. Partially metamorphosed, hard indurated, chocolate-colored shales, dipping northeastward, but much obscured by cleavage, passing up into red shales, 250 yards.

116. Dove-colored or light drab, fragmentary, sometimes earthy limestone, apparently forming a heavy bed, of which a thickness of 10 to 20 feet is exposed; overlaid by harder, rough-weathered darkish gray and drab, heavier bedded limestone, with obscure fossils. The rock, in places, weathered light yellowish drab, and is intersected by thin seams of chalcedony. Dip north-northeast, at an angle of 30°, more or less, and flagging the northeast face of the mountain.

Station XX affords a fine view of the mountain summits to the south and southwest, but to the north higher crests shut out the view of the northern end of the range. Looking down the great spur-like ridge which descends along the north side of Fall Creek Cañon, we gain a pretty clear knowledge of the lithological characters of the rocky strata and their distribution in the space embraced between Station XX and the nearest point on Snake River, six miles to the northeast, just above the entrance to its lower cañon in the basalt. Without presuming to give the actual dip of these strata, which the distance did not allow of satisfactory determination, their appearance has been incorporated in the diagram of the above referred to section, and which may be briefly noticed as follows: Outlying the summit of the station on the northeast, and beneath which its limestone mail passes in its northeasterly inclination, the first break or double parallel ridge shows (117) a heavy deposit of red beds, largely composed of soft materials, with beds of brown and red sandstone. Next beyond, in a narrow succeeding ridge, is seen (118) a series of light drab bands, merging below into the reddish shales of the preceding. Next occurs a wide and very broken belt, one to two miles across, in which appear (119) heavy deposits of red-colored beds; then succeeds a lower and narrower ridge, made up of (120) light-colored beds, followed by (121) a partially exposed red-bed ridge, apparently lying near the valley-side, south of the Snake. The strata of the two first series (117, 118) evidently dip with the limestones (116) in Station XX; but in the ridges beyond it was impossible to determine more than the general lithological peculiarities of the strata, which were seen to cross the spur in parallel bands. However, to the north we were able to extend our examinations into the belt of deposits here referred to, and the results will be alluded to presently.

In passing up the south spur of Station XX, at a point about a mile from the station, an interesting exposure of the same series of strata shown in the foregoing section occurs in the northwest side of the gulch. The limestone and sandstone beds, 85 to 89, and others, have the appearance of having been quite overturned, so that these beds as shown in the section actually occupy an inverted position. Farther up the gulch, here and there exposures of light gray limestones are traced in the upper slopes, their outcrop nearly horizontal or gently inclined northerly, as though they constituted part of the roof of a broad-topped anticlinal fold, in the southern flank of which the strata were toppled over past the vertical, while in the opposite or northern flank they hold their natural relative position, where they are overlaid in order by the super-

imposed series of red deposits which, probably, in part, at least, pertain to a geological epoch as late as the Laramie. The few data afforded by the fossils in the upper limestones of the preceding section are ample to determine their Jurassic age, and so, also, of the lower limestones in the present section; and although their exact equivalents in the two sections may be left unsettled, they cannot be far removed; the bed 85, if it is not identical with that of the same number in the former section, cannot be far removed from that bed or overlying it in the inverted position of these strata. At the latter locality it was observed that the plant-bearing sandstones and the associated red shales, which, under any circumstance, would not be referred to a period more remote than the Cretaceous, while they are believed to be not older than the Laramie, pitch into the mountain-side where they occupy a position apparently conformable to and underlying well-determined Jurassic horizons. If the appearances above alluded to are correctly interpreted, and there seems to be no other interpretation admissible, then we have the otherwise anomalous position of these strata fully explained in their being involved in disturbances which resulted in their upheaval and inversion. There is no evidence of faulting in the strata at this point by which the relative position of the plant-beds might be attributed to a downthrow on the south flank of the uplift. Hence, on the strength of the observed facts and inferences derived from all but as good sources, in reproducing the sections across this part of the range, the structural features are given in accordance with the above-expressed conclusions.

Assuming the inversion of the strata south of Station XX, it is apparent that the arch of the fold has been completely denuded in the mountain ridges bordering on Fall Creek Cañon. But to the north there are signs, as above mentioned, of the existence of remnants at least of the beds that spanned the great fold. If the uplift represented a displacement of hundreds or even a few thousands of feet, the work of erosion has more than half demolished the structure erected by the dynamic agents which uplifted and corrugated the accumulations of ages of deposition on the ancient sea-beds.

The northwesterly extension of Station XX ridge shows here and there remnants of the peculiar rusty vesicular lava, the disintegration of which has strewn the surface with fragments of obsidian. These vary in color from jet black through various shades of lavender to drab, with spherulite disseminated through their mass. The obsidian appears to have been in concretionary masses, probably imbedded in the lava. At numerous points along this ridge, red shales and even sandstones appear to have been more or less changed by metamorphic action, probably derived from proximity of the volcanic material. The relation of this rock to the sedimentaries was not satisfactorily revealed here; but it seems most probable that these remnants belonged to an immense flow which spread over the high lands when their surface was more even, or before erosion had fashioned it into its present complicated topographic reliefs. The deposit here reaches an altitude of about 7,400 feet; and was again met with a few miles to the northwest, where it apparently forms a part, at least, of the volcanic cap of high benches sloping off in the direction of Willow Creek.

About a mile northwest of Station XX, in a corresponding height, a heavy ledge, of brown weathered sandstone appears, dipping west of south at an angle of 35°. Between this point and the station, a similar brownish-red laminated sandstone outcrops in the crest of the ridge beneath the lava, where it dips at an angle of 45° to the north-northeast. It is associated with red indurated shales, and probably holds a stratigraph-

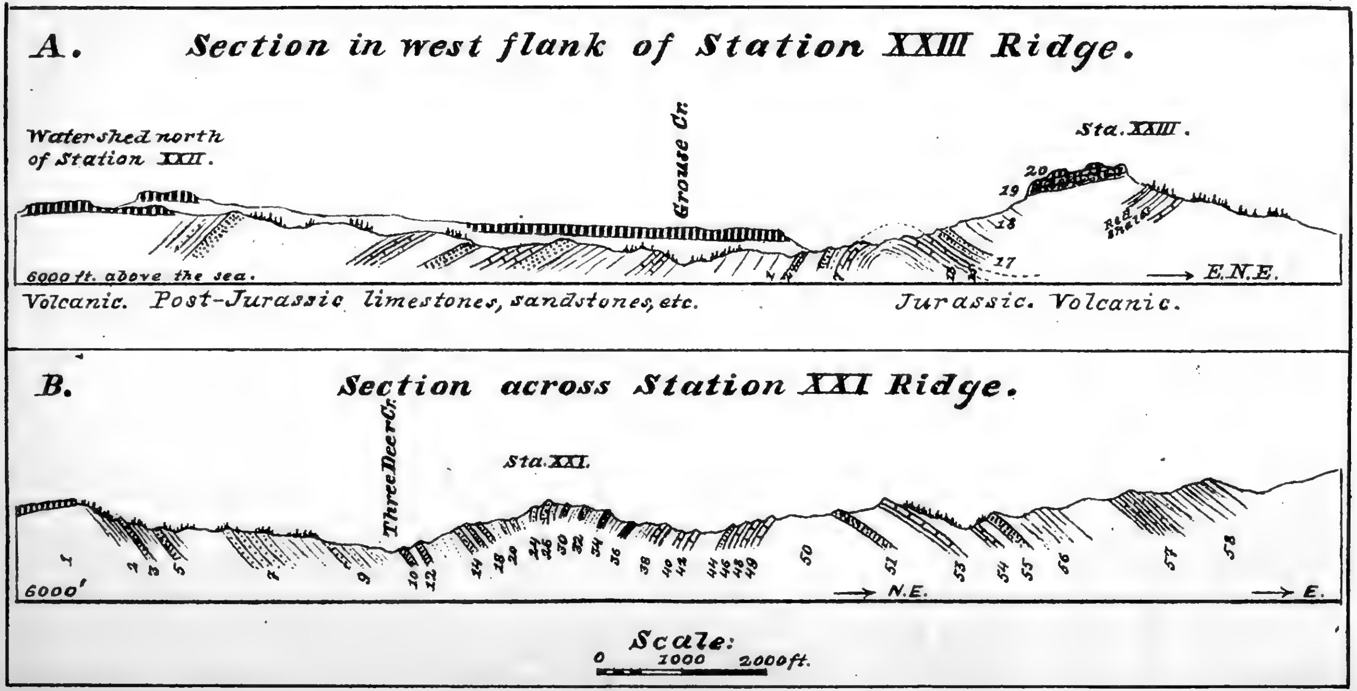
ical position inferior to the limestone in Station XX. Descending the spur westerly into the pretty little valley of a tributary of the middle fork of Willow or Porcupine Creek, perhaps half a mile from the above-mentioned height, a heavy ledge of drab-gray limestone forms a vertical dike, or hog-back, extending in an east-west direction diagonally across the ridge. It is followed by a similar though lower ledge, inclined steeply southward; as also does the first mentioned in places. These ledges are apparently Jurassic, and probably belong to the Station XX uplift.

In the low, grassy, undulating slopes bordering the little valley of Porcupine Creek, which is hemmed in on the south by the high volcanic-capped bench two or three miles west of Station XX, the surface shows frequent, though obscure, exposures of red shales and gray sandstones. But to the west, these soon pass under the volcanic flows which slope down into the general level of the volcanic upland in which Willow Creek is deeply cañoned. A similar but more isolated volcanic bench borders this little valley on the west, and which has from this point of view a butte-like appearance; but on gaining the summit (7,200 feet), it is found to be a plateau, sloping westward, and protected by a heavy covering of drab and pinkish trachyte, and yellow laminated readily decomposing varieties with mica flakes, which splits into thin uneven slabs, giving to the rock a bedded appearance. It clearly rests upon the denuded edges of the tilted sedimentaries, but no trace of the previously mentioned vesicular obsidian lava was here observed. This butte-like plateau is about four miles due west of Station XX, and little more than a mile southwestward of Station XXI, from which it is separated by the sag of Three-Deer Creek, which flows into the Porcupine; the southwest side marking the limits of the continuous volcanic formation, while to the northeast and east the hills are mainly sedimentary. A section carried from this point along a northeasterly line, passing through Station XXI, is given below:

Section through Station XXI.

1. Trachytic cap of plateau between Porcupine and Three-Deer Creeks.
2. Red shales and soft gray sandstones.
3. Soft, false-bedded, shaly, gray sandstone, 15 feet exposed; dip 50, N. 45° E. This ledge is partially concealed high in the northeast face of the volcanic-capped plateau, but in the lower ground to the south-east it is traced as a low hog-back ridge extending down into the Porcupine Valley.
4. Red shales, 200 yards across the exposure.
5. Coarse, crumbling, rather even-bedded gray sandstone, 5 feet exposed, in low wall in the northeast flank of the volcanic plateau. Dip 57°, N. 40° E.
6. Obscure exposures of blue and red shales and gray indurated sandy beds, with calcite, 300 yards.
7. Soft gray sandstones with reddish shales, terminating below in—
8. Heavy ledge of soft, shaly, gray sandstone, 10 to 20 feet exposed.
9. Slope to Three-Deer Creek, showing obscure exposures of soft gray sandstone, with calcite fragments in the soil, 400 yards.
10. Gray, thin-bedded sandstone, in low bluff 50 yards northeast of the stream-bed.
11. *Débris*-covered slope, 75 yards.
12. Coarse, thin-bedded, gray sandstone, 10 feet exposed; dip 55°, N. 45° E.

PLATE XX.



A. Section in west flank of Station XXIII Ridge.
Watershed north of Station XXII.
Grouse Cr.
Sta. XXIII.
Red shale
17
18
19
20
6000 ft. above the sea.
E.N.E.
Volcanic. Post-Jurassic limestones, sandstones, etc.
Jurassic. Volcanic.
B. Section across Station XXI Ridge.
Three Deer Cr.
Sta. XXI.
1
2
3
5
7
9
10
12
14
18
20
24
26
30
32
34
36
38
40
42
44
46
48
49
50
51
53
54
55
56
57
58
6000'
N.E.
E.
Scale:
0
1000
2000 ft.

13. Red and chocolate-colored, partially indurated shales, in slope 160 yards across.
14. Rusty-stained sandstone, 5 feet exposed.
15. *Débris*-covered slope, 50 yards.
16. Thin-bedded gray sandstone, 5 feet; dip 45°, N. 45° E.
17. Chocolate-colored shales, 50 yards.
18. Brown-stained laminated sandstone, 5 feet exposed.
19. *Débris*-covered slope, 100 yards.
20. Gray sandstone, obscure ledge.
21. *Débris*-covered slope, 20 yards.
22. Gray sandstone, obscure exposure.
23. Steep slope, with red shales, 110 yards.
24. Hard, thin-bedded, laminated, rusty-gray sandstone, 5 feet exposed, but evidently much thicker; dip 50°, S. 35° W. Contains obscure vegetable impressions with a narrow salix-like leaf.
25. Unexposed space, 35 yards.
26. Hard, brittle, laminated, rusty-gray sandstone, 10 feet exposed in ledge forming crest of Station XXI ridge; dip 55°, S. 35° W.
27. Slope, no exposure, 50 yards.
28. Brownish gray sandstone.
29. Red shales, 50 to 75 yards.
30. Gray sandstone, 10 feet exposed, dip southward.
31. Red shales, 50 to 75 yards.
32. Hard, thin-bedded, bluish-gray, brown-stained sandstone, heavy ledge 50 to 60 feet across the exposure; dip southwestward.
33. Red shales, 30 yards.
34. Gray sandstone, like 32, 10 feet exposed; dip 45°, S. 45° W.
35. Red shales, 100 yards or more.
36. Bluish drab, fragmentary limestone, obscure exposure.
37. Light drab indurated argillo-calcareous deposits, exposed at intervals, 100 to 200 yards.
38. Drab limestone and indurated light-drab calcareous shales, obscure exposure.
39. *Débris*-covered slope, with small irregular dark carbonaceous nodules in upper part, 50 to 100 yards.
40. Drab, fragmentary limestone, 5 feet exposed.
41. Red shales, 50 yards.
42. Drab, fragmentary limestone, 20 feet exposed; dip 55°, S. 40° W.
43. Red shales, 100 to 150 yards.
44. Gray and brown conglomeritic, spar-seamed sandstone, sometimes coarse-grained, crumbling, flagging, 10 feet exposed; dip 50°, S. 50° W.
45. Red shales, 75 yards.
46. Drab, minutely brecciated, spar-seamed limestone with comminuted fossils, obscure exposure, dips southwestward.
47. *Débris*-covered space, 20 yards.
48. Drab, fragmentary, spar-seamed limestone, 12 feet exposed. Dip 50°, S. 45° W.
49. Limestone, like bed 48, heavy ledge exposed at intervals over a space 75 yards across.
50. Red shales, appearing in slope 200 to 300 yards across.
51. Gray and brown friable sandstone flagging, 20 feet exposed; dip 25° to 35°, N. 45° E.
52. Red shales, exposed in sag, 200 yards or more across.
53. Drab, close-textured, fragmentary limestone, much broken up by cleavage and joint structure; apparent dip N. 45° E., at an angle of 35°. This rock occurs as a heavy ledge in the crest of a high ridge

about one mile northeast of Station XXI. The southwest face in places shows a low mural exposure, in which the surfaces slope southward at an angle of 85°; but this appearance is probably due to the cleavage planes.

One and a half miles to the north and east the surface rises into still more elevated heights which form the culminating crest of this portion of the range—800 feet higher than Station XXI or 8,000 feet above sea-level. The deposits observed in this slope are as follows:

54. Light-drab calcareous deposits, apparently a heavy bed consisting of limestones and indurated argillo-calcareous shales.

55. Brown ferruginous sandstone, much broken up and dipping northeastward, forms a heavy ledge in crest of low ridge opposite side of deep gulch, perhaps a quarter of a mile distant from the limestone ridge at bed 53.

56. A heavy series of reddish deposits, perhaps half a mile across.

57. Light-drab indurated calcareous deposits overlaid higher in the slope by still heavier deposits of—

58. Reddish beds terminating in ridge half a mile below summit of the high barrier ridge.

The occurrence and apparent relative position of the latter series of deposits are indicated in the diagram of the foregoing section. The age of the limestone beds north of the station was not determined from paleontological data; but that the southern exposures of gray sandstones and red shales are clearly identical with the plant-beds in the mountain basin of Fall Creek would seem to warrant the reference of the limestones to the Jurassic. The sudden change in the inclination of these strata, from a northerly dip in the southwest slope to southwesterly inclination in the crest of the ridge at the station, seems to mark the position of the axis of the inverted strata involved in the overthrow of the fold; indeed this is quite clearly shown to be the fact in the exposures to the southeast, where the strata are seen to curve over in reversed position. At all events, the identity of the phenomena observed here with what obtains in connection with the same set of strata in the vicinity of Station XX and in the upper basin of Fall Creek is quite apparent.

Looking northwest, in the direction of Station XXII, the crest and northeast-lying ledges of Station XXI pass along the broken slopes in the order in which they are represented in the above section, the strike wavering slightly from a direct course and trending round more into an east-west and south-of-west direction as they approach the former station. This is indicated in the position there assumed by the crest sandstone of Station XXI, which is seen to curve over in a low-arched fold, with gentle inclination west of north. This feature is further and better explained by reference to an accompanying sketch, and will be more particularly alluded to presently. About one and a half miles north of Station XXI and the same distance little south of east of Station XXII, the watershed runs up into a high, isolated dome, 7,600 feet above sea-level, which is crowned by a heavy cap of trachyte similar to that in the high plateau southwest of XXI, but here associated with the rusty, vesicular, obsidian-bearing lava mentioned as occurring in the crest near Station XX. These deposits incline at a moderate angle southwesterly, but do not reach the elevated volcanic plain as at the former locality, erosion having formed a wide gap, separating this remnant from a similar sloping plateau which descends into the plain west of XXII. The *débris* from the volcanic rocks conceals the sedimentaries in the slopes, but in the steep declivity on the northeast side

of the mountain a thick ledge of hard, darkish gray, laminated sandstone is exposed in a low wall which sweeps down into the deep gulch in the direction of the exposure of bed No. 55 of the preceding section, with which it is either identical or but little removed to the north. The dip of the bed here is north-northeastward at an angle of 45°. In the opposite direction the same narrow comb is still traced in the flank of the ridge towards Station XXII, the trend curving gently round into a course south of west. In a lower eminence of the ridge, west of the trachyte dome, occurs a heavy bed of hard, reddish-gray, laminated sandstone, in thin layers, very like that last-mentioned above, and dipping at an angle of 40°, N. 10° W., though variable, as though it formed part of the undulating arch of a low dome or fold. It is here overlaid by a ledge probably the same as that in the trachytic dome, which outcrops in the north flank 300 yards below the crest. To show the variable lay of these strata, even within short distances, at one point in the west end of this eminence the bed dips westward at an angle of 20°, and in the low connecting ridge just beyond the dip is to the N. 5° W., at an angle of 30°. These beds are apparently underlaid by a ledge of dirty brown, minutely brecciated or conglomeritic gritty limestone, upon which rests a gray sandstone; and in the summit of the high point half a mile east of XXII, there appears a still higher heavy ledge of gray, reddish-tinged, laminated sandstone, changed almost to the condition of quartzite, dipping 40°, N. 15° W. The latter may belong to one of the previously mentioned ledges.

Passing from the last-mentioned point to Station XXII, the summit of the mountain is found to be capped by a much broken up exposure of flesh-tinted, gray, intensely hard sandstone, dipping northwestward. In the southeast declivity, about 200 feet below the summit, the descent is broken by a low mural exposure, which forms so conspicuous a feature in the mountain-side as seen from Station XXI. This wall shows a thickness of 15 feet or more of very hard, laminated, gray, reddish-tinted sandstone, almost a quartzite, which, at the point examined, dips 15° to 20°, N. 5° E. In a less marked bench intervening between the above and the summit, a heavy ledge of thin-bedded, gray sandstone outcrops, with a dip of 40°, N. 45° E. The lower ledge is, as previously observed, identical either with that forming the crest of Station XXI or the next ledge to the south, the bed and associated strata at the present locality apparently holding an inverted position.

The above somewhat disconnected observations are introduced with the view of presenting all the leading data possessed that may aid to a fair elucidation of the complicated structural features pertaining to the west flank of the northern portion of the range. It would appear that, in this northern country, phenomena of the kind here mentioned are by no means of rare occurrence; but in the present instance, to the writer at least, they were of so great interest, and in spite of our opportunities, or their lack, not quite worked out to our perfect satisfaction, that it was deemed preferable to give a summary of the detail examinations on which the conclusions arrived at were based, that they may be shown to be consistent with the facts so far as observed.

Station XXII occupies a commanding position on the western verge of the range at the head of Smoke Creek (east fork of Willow Creek), immediately overlooking the west-sloping volcanic plateau which terminates in a line of steep, high bluffs, fronting the station on the west and northwest, and which were once continuous with the similar benches either side of Porcupine Creek. These volcanics, as at the latter locality, gently slope to the level of the volcanic-floored upland bordering the

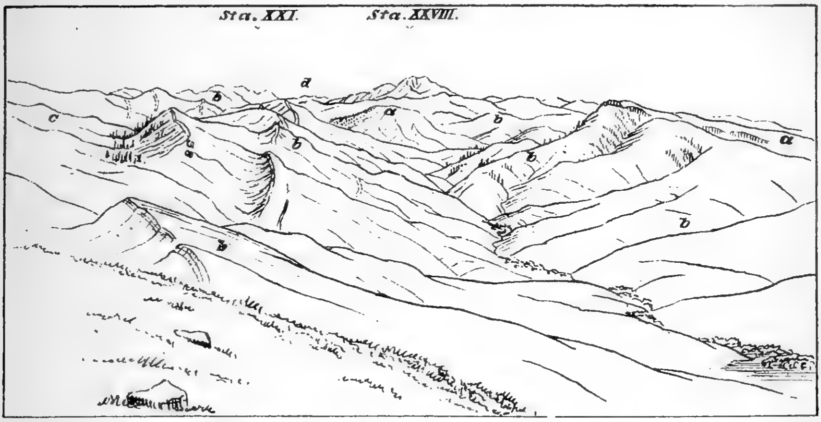
hills. To the southwest a belt of low grassy foot-hills sweeps round the northern border into the debouchure of the Snake, in which highly tilted reddish-brown strata appear, overlaid by volcanic flows whose *débris* forms bare rocky slides in the high declivities, like the disintegrated outcrops of volcanic-filled fissures or dikes in the sedimentary formations. The volcanics, indeed, sweep up on the higher eminences, crowning isolated points on the watershed within a short distance north of Station XXII, increasing in consequence farther north, where they doubtless still envelope quite extensive summit areas, and remnants like that on the high point between the last two stations were met with on the northeast flank of the range. These higher deposits are trachytic and rusty vesicular lava or porphyritic trachyte, the latter often met with in bowlder-like masses. Crater Buttes and the Sand-Hills appear near at hand, though 30 or 40 miles to the northwest, the mirage mimicking a lake expanse at their base. The Three Buttes, huddled together from this direction, are seen far away to the southwest. Haze fills the great plain of the Snake, on the farther side of which the crests of the distant lofty ranges of the Salmon and Boise appear like phantom mountains, their bases buried in the evening gloom, and their summits lighted up with indescribably delicate tints, only less brilliant than the glow of the western sky into which the more distant ranges dimly fade. But at a later hour, when the light has faded, and the sky an even silvery blue, against which the mountains are projected in sharp relief, the grandeur of the effect is almost inconceivable. These early morning and evening studies compensate a thousand fold the midday weariness of the shimmering plain and shadowless mountains and low overarching brazen sky.

Crossing around the narrow northern end of the range, the gray sandstones and red shaly deposits are met with along the western flank in the shallow valleys hemmed in by the trachytic flows, and a few miles north of XXII, these deposits pass out into low, rounded, grassy hills, where they appear as variegated beds over a limited area, but are soon hidden beneath the encircling volcanics. The sedimentaries appear in a low, broken ridge at the north end of the watershed, from the foot of which spreads a gently undulating plateau bench, to the north sinking into the volcanic upland, which descends into the broad debouchure of the Snake. The low ridge is composed of heavy ledges of gray and reddish laminated sandstone and shales, with drab and gray fragmentary limestones, the southerly dip gradually lessening from an angle of 50° on the southwest border of the ridge to 15° in the western border of the plateau, in which latter quarter these deposits seem to form the roof of a low-arched fold. To the east the plateau is floored by volcanic rocks, consisting of the vesicular lava and trachytic *débris*, and extending across to the eastern border, where they show heavy ledges in the coping of the high bluffs on Grouse Creek. The sedimentaries above alluded to are doubtless the series shown in the section through Station XXI, belonging, however, to a fold on the north of that represented at the latter locality.

In the angle between Grouse Creek and the Snake the culminating crest of the range terminates in the height selected for Station XXIII, from which the view, looking northward out over the debouchure of Snake River, gives at a glance the relations of this bay-like expanse to the converging mountain barriers, which, a little higher up, define the border limits of the lower valley of the Snake and its southern extension up Salt River south of the grand cañon. This indentation belongs properly to the upland volcanic region, which everywhere in this quarter margins the great plain—a sort of transition from plain to highlands—

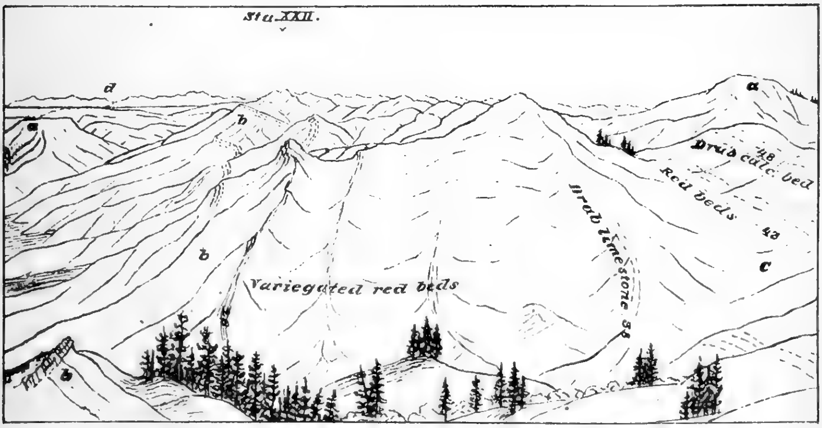
PLATE XXI.

WEST SLOPE OF THE CARIBOU RANGE.



From Station XXII, looking S.E.

a. Trachyte. b. Post-Jurassic beds, locally inverted.
c. Jura. d. Wind River Mts. (?)



From Station XXI ridge, looking N.N.W.

a. Volcanic. b. Post-Jurassic, inverted. c. Jurassic.
d. Snake Plains and Salmon River Mts.

and, as is the case with all these wide recesses, like the Blackfoot, Willow Creek, and Pierre's basins, the debouching river, immediately it leaves its valley course to cross this upland tract on its way to the plain, enters the "lower cañon," which it has excavated deep into the volcanic materials that fill the recess. On the northeast side of the valley the Snake River Mountains gradually descend and run out in a long, narrow, rocky spur, flanked by the volcanic benches. The southwestern flank of this range we did not again approach nearer, the heights on this side affording excellent opportunity for studying its topography, while the unfordable state of the river prevented its passage at any higher point for the purpose of making closer examinations of the geology of the mountain front, which for several days was provokingly near.

Beneath the trachyte in the steep slopes on Grouse Creek chocolate-colored shales appear; but in the opposite slope, descending from Station XXIII, a couple of miles to the southeast, the sedimentary beds are again revealed, affording the following section:

Section through Station XXIII.

1. Chocolate-colored shales, in bluff on west side of Grouse Creek, overlaid by drab and pink trachyte, dipping gently northwestward.
2. Gray, brown-weathered, thin-bedded sandstone, 7 feet exposed in foot of slope east side of Grouse Creek; dip 58°, S. 65° W.
3. *Débris*-covered slope, 120 yards.
4. Dark bluish-gray, rusty brown weathered, fragmentary, coarse, gritty limestone, 5 feet exposed; dip 63°, S. 65° W.
5. Gray, brown-stained sandstone, obscure exposure, space 85 yards.
6. Red and chocolate-colored shales, space 45 yards.
7. Chocolate-colored and drab fragmentary limestone, and drab indurated or nodular calcareous deposits, obscure exposure, 35 yards. Dip 30°, S.
8. Red and chocolate-colored shales, space 75 yards.
9. Dark-gray, gritty ledge, obscure exposure.
10. Bluish-gray, brown-weathered sandstone, obscure.
11. Unexposed, space 9 to 11, inclusive, 35 yards.
12. Red and chocolate-colored shales, space 25 yards.
13. Dark chocolate-drab, brittle, fragmentary limestone, 15 yards across the exposure; dip gently northeastward.
14. Chocolate-colored and red shales, 50 yards.
15. Rough, fragmentary, chocolate-brown limestone, obscure ledge.
16. *Débris*-covered slope, 50 yards.
17. Rusty conglomeritic deposit, associated with fine, grayish, laminated sandstone above, forming a heavy ledge 15 to 20 feet exposed; dip 20°, N. 55° E.
18. *Débris*-covered slope, with fragments of light-bluish limestone with unrecognizable fossils, 50 to 100 yards.
19. Heavy conglomeritic ledge, forming irregularly eroded mural exposures, 30 feet, more or less, in height, encircling the brow of the hill, and showing an inclination to the north or northwestward at an angle of 20° to 25°. This ledge is very variable in the nature of its components, in places appearing as a variegated trachytic tuff, in color, buff, chocolate-red mottled, drab and pink-drab, with small dark specks. But the most characteristic feature is its conglomeritic structure, showing a variety of slightly abraded coarse materials, chiefly quartzite with small fragments of limestone, ranging in size from gravel to small bowlders, arranged in layers and impacted in a light-buff fine paste.

20. Coarse vesicular, rusty lava, occurring in abraded bowlder-like masses in the sloping plateau-like summit at Station XXIII.

The rock last mentioned above is probably the same as that previously mentioned as occurring in the watershed summits in the vicinity of Stations XX, XXI, and northward. Only here it is associated with an inferior fragmental deposit, possibly also of volcanic origin, the presence of which is of more than ordinary interest for the evidence it furnishes of the character and relative position of a kind of volcanic products not of infrequent occurrence in this region.

It is apparent that the sedimentary deposits in the northwest flank of XXIII are the same as those met with on the west slope of the range a few miles distant, and it is not improbable that the limestones prove to be Jurassic, though the few traces of organic remains, unfortunately, are not in a condition suitable for identification. In the steep south and southeast slope, red shales show here and there, 100 to 200 feet beneath the conglomerate, whose disintegration has strewn the declivity with *debris.* In the foot of the declivity, perhaps a quarter of a mile south of the summit, a ledge of drab, gray-mottled, rough weathered, sparseamed limestone appears, showing an exposed thickness of 8 feet, and dipping 35°, N. 40° W. It contains a few fragments of *Ostrea strigulecula (?)*, determining its Jurassic age. From the latter point the saddle ridge extends southward to a high plateau-like summit, one and a half miles distant, in the slightly tipped up east and southeast rim of which there appears a ledge of rusty vesicular lava, inclining gently northwestward with the surface, which is covered with groves of fir and aspen and open grassy glades. Midway and to the south along the connecting spur, heavy ledges of gray and light drab heavy bedded limestones, including a bed of reddish gray laminated sandstones, 5 feet exposed, and red shales, lap up on the western flank, and at one point arch over the ridge in an anticlinal fold, with dips N. 35° to 55° E., at angles of 25° to 45° on the one hand, and S. 40° W., at an angle of 25°, more or less, in the opposite flank. The limestones of the west flank of the fold form a rocky spur leading up to the summit of the plateau, where they pass from sight beneath the volcanic flow. Bowlder-like masses of the latter, with fragments of black obsidian, were found scattered along the crest of the saddle-ridge; but the volcanic conglomerate was not again detected in the high mountain summits.

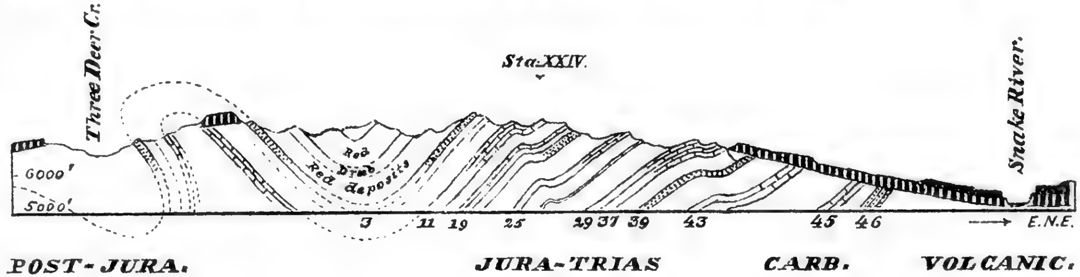
The sedimentary beds above alluded to are very variable in the direction of their strike, so much so as to greatly increase the difficulty of tracing the folds into which they have been uplifted for any distance in so broken a country as this. From what we have been able to learn, it would appear that the strata, in this northern portion of the range, have been subjected to disturbing agencies even more complicated in the result of their action than what obtained in the range to the south.

In the southeast flank of the little mountain plateau the sedimentary ledges again appear, where, as seen from Station XXIV, they exhibit an interesting abrupt fold, which has every appearance of being inverted on the northeast. The exposed strata involved in this overturn seem to be identical with the exposures observed in the before-mentioned fold in the saddle-ridge on the opposite side of the plateau. These beds again appear in the crest of the ridge just southwest of Station XXIV, where, however, they are simply uplifted into a low arch of quite subordinate importance, forming merely a wrinkle in the generally southwesterly inclined strata.

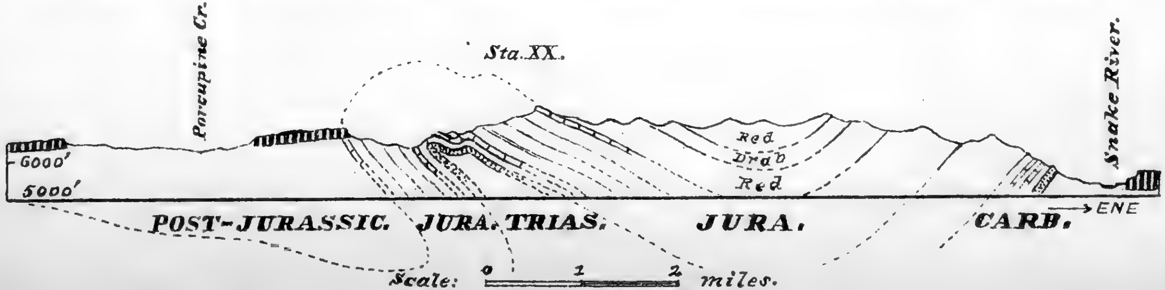
Half a mile or so southeast of the volcanic-capped plateau, with which

PLATE XXII.

SECTION ACROSS THE CARIBOU RANGE, VICINITY OF STA.N XXIV.



SECTION ACROSS THE CARIBOU RANGE, NORTH OF FALL CREEK.



it is connected by a deep saddle, rises a high conical peak (about 7,600 feet), the crest of which is formed by a heavy ledge of hard reddish buff sandstone or quartzite, much broken up by cleavage and joint structure, and dipping southwestward. This ledge runs obliquely down into the cañon on the south, and thence climbs the steep slopes to the crest of the opposite ridge, where it forms another rugged comb outlying the highest summit of the range north of Fall Creek; to the northwest it soon passes into the volcanic mountain-plateau and is soon lost to view. On the southwest flank of this peak 100 feet below the summit a similar heavy ledge of darker rusty gray and buff laminated quartzite, or hard sandstone, forms a dike-like comb skirting the hillside, in which a thickness of 20 feet is exposed, dipping apparently N. 50° E., at an angle of 75°. The relations of this ledge to that occurring in the summit, from which it differs mainly in its darker color, were not clearly displayed. In the ridge to the southeast, where its accompanying ledge is well exposed, there is no indication of these strata being folded into a sharp synclinal, and its position here may be due to disturbances of merely local extent. This peak is about two and a half miles northeastward of the previously mentioned trachytic-capped dome on the watershed equidistant between Stations XXI and XXII. In the interval between these two points, an extremely broken region on the headwaters of Grouse Creek, the same series of strata occur as was noticed in the belt on the northeast flank of the range between Station XX and the Snake, four miles to the southeast of the present locality, and also northeast of Station XXI midway between the two latter points. The interval here consists of alternating belts of red shales, reddish and gray, brown weathered sandstones, bluish limestones and light drab calcareous deposits, none of which are exposed continuously over any considerable area, but appear here and there in isolated patches in the steeper slopes and crests. The above deposits, extending over to the trachytic-capped dome, are introduced in the following section, connecting with the examined horizons in the section through Station XXI. The present section from the quartzite peak passes along a line northeast to Station XXIV three-quarters of a mile, thence in a nearly easterly direction four and a half miles, to the nearest point on Snake River, and is as follows:

Section through Station XXIV.

a. Red deposits, occupying a wide belt, and perhaps identical with bed No. 58 of section through Station XXI.

b. Red and light-drab deposits, the latter probably limestones and indurated calcareous shales.

c. Light-drab deposits, occurring in a narrow belt, and may be the same as the light band under last above number.

d. Heavy deposit of red beds, sandstones and shales, apparently dipping southwestward.

e. Drab calcareous deposits.

f. Red deposits, sandstones, &c.

1. Quartzitic sandstone, 20 feet exposed; dip 75°, N. 50° E.
2. Unexposed space.
3. Similar quartzitic sandstone, a heavy ledge; dip southwestward.
4. Blue and drab shales, with indurated ferruginous gritty layers and nodules in alternating thin bands, 60 feet; dip 45°, S. 40° W.
5. Dark brown, shaly, ferruginous gritty limestone, underlaid by a greater thickness of gray arenaceous rock, 10 feet exposed; dip same as last.

6. Chocolate-colored shales, 60 yards across the exposure.

7. Heavy-bedded, hard, gray limestone, obscure exposure.

8. Reddish shales, thick deposit.

9. Gray sandstone, obscure exposure, 200 yards N. E. of bed 3; dip 50°, S. 55° W.

10. Red shales, 100 yards.

11. Heavy-bedded, rough-weathered, bluish-drab limestone, much fractured by joint and cleavage structure; dip 50° to 55°, S. 50° W.

11*a*. Drab, spar-seamed limestone, probably belonging to preceding bed, curved over and forming part of an arch, as seen at—

11*b*. Limestone same as preceding; dip N. 45° E. at an angle of 18°, more or less.

11*c*. Limestone, similar to the preceding bed, exposed in foot of acclivity rising into Station XXIV; dip southwestward at an angle of 30°.

11*d*. Limestone, similar to preceding, bedding much obscured by joint and cleavage structure, exposed 20 feet; dip 30°, W. 20° N. Forms summit ledge at Station XXIV. The limestones mentioned under the above numbers, 11–11*d*, appear to be inverted in a sharp fold in the opposite side of the gulch to the northwest, as mentioned in a preceding page.

12. Red shales, 50 yards.

13. Reddish-gray sandstone, beautifully laminated, a heavy bed, 10 feet exposed; dip 25° to 30°, westward.

14. Unexposed.

15. Sandstone, similar to preceding bed.

16. Unexposed.

17. Sandstone, like the preceding.

18. Reddish chocolate-colored shales.

19. Dark brown and gray, gritty, shaly limestone, with *Ostrea strigulecula* (?), underlaid by gray shaly sandstone, 20 feet exposed; dip 30°, S. 65° W. Outcrop 200 to 300 yards below bed No. 13.

20. Unexposed, 20 to 30 feet.

21. Heavy-bedded reddish sandstone, 20 feet exposed.

22. Red shales, 50 to 75 feet.

23. Thin-bedded, reddish-gray sandstones, with ripple markings, 15 feet exposed. These heavy sandstone ledges are finely exposed in the slopes on the opposite side of the cañon to the southeast.

24. Dark blue and chocolate-colored shales, 100 feet or more, exposed in saddle.

25. Heavy-bedded gray limestone, with obscure spiculæ and *Pentacrinus* remains, exposed 10 feet; dip 25°, W. 30° N. The bluff or transverse ridge outcrop of the ledge is some 300 or 400 yards below the bluff exposure of bed No. 19, the west-facing slope being covered with limestone *débris* to the saddle.

26. Drab or blue indurated calcareous shales.

27. Drab limestone, obscure bench exposure.

28. Reddish and drab shales.

29. Drab, brittle limestone, even bedded below, exposed 15 feet, 400 to 500 yards below bed No. 25. Dip 25°, west.

30. Unexposed space, 50 to 75 yards.

31. Dark drab, fragmentary, spar-seamed limestone, 15 feet exposed. Dip 32°, W. 5° S.

32. Unexposed space, 30 to 50 yards.

33. Blue, drab-mottled, rather even-bedded limestone, like No. 31, containing *Ostrea strigulecula* (?). This ledge here makes a slight fold or wrinkle, gently inclined on the southwest, but more steeply pitching on

the opposite side at an angle of 30°, N. 35° E., and again gently rising to the northeast, where it forms a low bench outcrop 50 to 75 yards from the axis of the fold. A thickness of 20 feet is exposed.

34. Red shales, space 40 yards.

35. Drab, fragmentary limestone, obscure outcrop.

36. *Débris*-covered slope, 25 yards.

37. Uneven heavy-bedded buff limestone, apparently interbedded or associated with drab limestone, 20 to 30 feet exposed. The buff ledge is variable in inclination, dipping at one point 28°, W. 45° N., and a few yards to the east changing to N. 30° to 45° E. at an angle of 30° to 35°, in the direction of the general slope, and passing under the trachytic ledges which here rest on the crest of the ridge. The buff limestone much resembles a tufaceous spring deposit.

38. Drab and chocolate-colored trachytic *débris* in crest of spur-ridge apparently filling a gully or sag 200 to 300 yards across.

39. Reddish-gray and buff, hard, obliquely-laminated quartzitic sandstone, with slickenside surfaces and much broken up by joint and cleavage structure. Forms a heavy ledge, dipping 25° to 45°, S. 30° to 60° W.

40. Slope, with sandstone *débris* in low bench midway, 400 to 500 yards.

41. *Débris* of drab, indurated calcareous shales and nodular limestone, in brow of steep declivity.

42. Unexposed, 100 yards.

43. Heavy ledge of light and dark drab limestone, 20 feet exposed, in prominent transverse ridge. Dip 45°, S. 50° W.

44. The main crest of the spur from the above ledge is composed of trachytic rock, which sweeps down into the valley, terminating abruptly in high bluffs on the Snake just above the entrance to the "lower cañon." The undulating crest of the ridge is covered with considerable quantities of water-worn pebbles and bowlders of sedimentary and other rocks.

45. Crossing over to the next spur-ridge on the southeast, in the slope perhaps half a mile from the last limestone ledge, 43, there appears the *débris* outcrop of light bluish spar-seamed limestone, which, lithologically, bears a strong resemblance to the Carboniferous limestones, although no fossils were here discerned conclusively demonstrating their age.

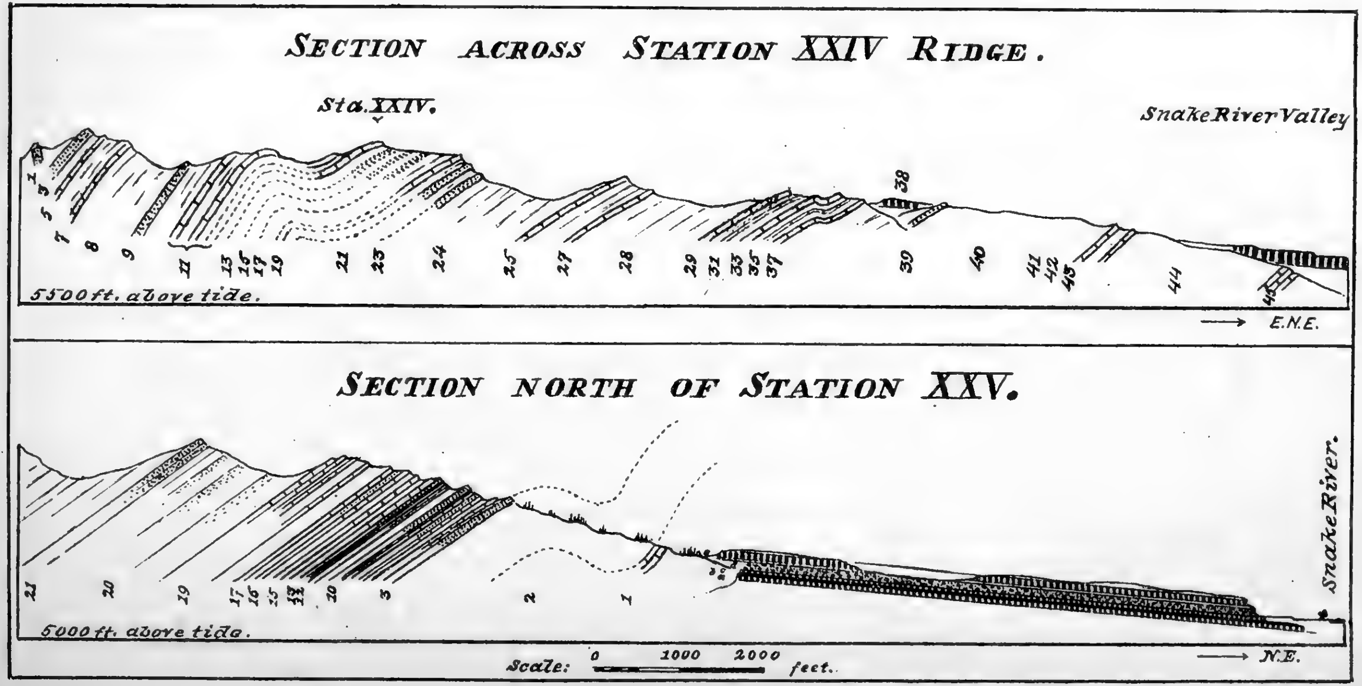
46. The above ledge is followed by a heavy ledge of pinkish-gray, laminated quartzite, dipping 50°, S. 55° W., which forms a narrow abutment ridge across the foot of the spur through which the little brook has cut a picturesque cañon passage just before it emerges into a miniature basin and flows out to join the Snake half a mile below.

The little basin at the foot of the above-mentioned spur on the edge of the Snake Valley, a few hundred yards distant from the quartzite wall, is partially hemmed in by a low conical hill 200 to 300 feet in height, which shows weathered masses of flesh-colored and drab trachyte protruding in the upper slopes, similar to that observed in the trachytic continuation of the main spur a mile or so to the north. The volcanic ledges here apparently rest upon a deposit of soft drab earth, but so imperfectly exposed as not to show clearly its character. It resembles the earthy material found in connection with the late Tertiary deposits and superimposed trachytic mantle, as seen at the before-mentioned localities in the vicinity of Station XXX, and elsewhere in the valley of the Blackfoot. The water-worn drift material alluded to under No. 44 of the foregoing section, is found scattered plentifully over this little butte, and chiefly consists of quartzite bowlders, with few of limestone. Similar occurrences of this erratic material were subsequently met with higher up the valley.

In regard to the age of the various deposits shown in the foregoing section, the probable post-Jurassic age of the variegated red shales and sandstones and calcareous deposits which appear in the belt of country lying to the southwest of the initial point proper of the detail section has already been remarked. Outlying the hard quartzitic ledge No. 3 on the northeast, a heavy series of drab limestone deposits, with interbedded variegated red, chocolate, and blue shales and reddish sandstones is met with, the fossil contents of which furnish conclusive evidence of their Jurassic age. It is difficult to estimate the thickness of this series, but it is probably not less than 2,000 feet, and this is believed to be considerably under the truth. The connection of this series with the limestones within the quartzite terminus of the spur, bed No: 45, was not traced, the slope being covered with volcanic materials and *débris;* but on lithologic grounds the latter deposits were compared with the Carboniferous. By reference to the report of Professor Bradley (Report U. S. Geol. Survey, 1872, p. 270), it is probable that this is the locality and these the identical exposures he mentions, after crossing to the southwest bank of the Snake below the mouth of Fall Creek, in which he saw "a few Carboniferous fossils." The latter series may extend up to, and include, the limestone bed 43, betwixt which and the Jurassic limestone, 35 and 37 (?), intervenes a rather wide belt, apparently filled with reddish-tinted brittle sandstones and softer materials, which occupy the position of the "red beds" of the Triassic series. The firmer ledges of this series are seen to good advantage in the opposite steep slopes on the south side of the cañon, where they are steeply inclined southwestwardly, as represented in the accompanying diagram of the section at this locality. The strike of these deposits, throughout the line occupied by the present section, is pretty uniformly southeastward and northwestward, the exceptions to this mean direction being few and merely local. Professor Bradley saw, probably a little below the point visited the present season, in connection with and succeeding the quartzite above, "coarse and fine white sandstones, and a very fine-grained white dolomitic limestone, all of uncertain age, though older than the overlying limestones," which latter have been identified with horizon No. 45 of the present section, in which he reported the finding of Carboniferous fossils. Hence it might be reasonable to infer the Silurian age of these basal deposits, whose tilted edges skirt the northeastern foot of the range, but for the fact that dolomitic limestones also occur in the Carboniferous.

Above the little trachyte butte the volcanics have been swept clear of the foot of the range, the Snake bottoms extending to the quartzite ledge which here forms the abrupt base of the mountain for a couple of miles, when the volcanics again occur in a high bench, reclining on the flank of the range. In the angles of the debouchure of Fall Creek, perhaps a couple of miles above its mouth, the flank of the range is composed of heavy deposits of bluish-gray limestones, probably of Carboniferous age, appearing in low foot-hills from beneath the volcanics, 500 or more feet above the river. As far up the winding and exceedingly rugged defile of Fall Creek as we can see, the sedimentaries dip up-stream, or southwestward. The quartzite which forms the base of the range at Butte Creek, three miles northwest, has been denuded at the latter locality, giving place to the Carboniferous, which holds this position for several miles to the southeastward, when it also passes into the valley space, and it is in turn replaced by the highly tilted red sandstones, as will be noticed more at length beyond. It would seem probable that the Carboniferous deposits formed a great arch, the opposite flank of which is

PLATE XXIII.



SECTION ACROSS STATION XXIV RIDGE.
Sta. XXIV.
Snake River Valley
1 3 5 7 8 9 11 13 15 17 19 21 23 24 25 27 28 29 31 33 35 37 38 39 40 41 42 43 44 45
5500 ft. above tide.
E.N.E.
SECTION NORTH OF STATION XXV.
Snake River.
21 20 19 17 16 15 13 11 20 3 2 1
5000 ft. above tide.
Scale: 0 1000 2000 feet.
N.E.

hinted in the northerly inclined strata of similar appearance, which make up the barrier on the northeast side of the valley in the quarter here referred to.

Three miles above Fall Creek, at the point where a little stream descends into the valley from the abrupt northern or front spur descending from Station XXV—one of the dominating points of the eastern front of the range between Fall and Pyramid Creeks which here attains an actual altitude of 9,000 feet, or 3,600 feet above the Snake—opportunity was afforded for the prosecution of some interesting detail examinations in the sedimentaries which here make up the northeast front of the range, the results of which are given below. This locality lies about three miles to the northwestward of Station XXV and four miles east-southeast of the debouchure of Fall Creek. As the little stream debouches from the mountains its bed lies in a cañon across the high volcanic bench which rests against the foot of the range, the relative position of which is shown in an accompanying section-diagram, the further notice of which is deferred to the section specially devoted to the description of the physical and geologic features of the lower valley of Snake River. This volcanic bench extends back from the river between one and two miles, when the base of the range proper is reached, where, on the west side of the little stream, that part of the section relating to the sedimentaries begins, extending thence in a south-southwest course to the crest of the before-mentioned front spur, and is as follows:

Section north of Station XXV.

1. Gray limestone, in places light granular subcrystalline, appearing in bench outcrop at foot of ascent, much broken up, and not satisfactorily showing the bedding. Dip probably southwestward, though at one point certain planes, probably joint structure, pitch to the N. 25° W. at an angle of 80°. Contains *Stenopora* or *Fistulipora*, crinoidal remains, *Fenestella*, *Spirifer*, *Productus*, a small *Platyceras*, &c., all characteristic forms of the Carboniferous. This outcrop is 800 to 1,000 feet above Snake River, the volcanics in places even reaching a higher level on the flank of the mountain.

2. Long slope, with no rock exposures *in situ*, perhaps half a mile, covered with groves of large pine, undergrowth, and open grassy plots.

3. Pink, laminated brittle sandstone, almost a quartzite, forming a heavy ledge, dipping gently southwestward, like the flagging of a dome or arch.

4. Bluish-drab, spar-seamed limestone, pertaining to a heavy ledge, and contains a large *Bellorophon*. The bed dips S. 45° W. at an angle of 30°, but at a neighboring exposure the inclination changes to N. 50° E., at an angle of 20°, indicating the axis of a fold or undulation in the strata. A few fragments of black obsidian were observed in the soil at this place.

5. Gray, heavy-bedded limestone, with irregular seams of rusty-gray chert or siliceous bands, in low bench exposure 75 to 100 yards south of No. 3. Dip 22° southwestward. Contains *Productus* and a large *Spirifer* like *S. cameratus*.

6. Unexposed, sag.

7. White, fine, granular magnesian (?) limestone, a heavy ledge, 10 feet exposed; dip 35°, southwest.

8. Reddish-buff indurated arenaceous bed.

9. Dark-blue and gray siliceous limestone, with dark chert; heavy bed, dip 35°, S. W. *Spirifer*, *Pleurotomaria*.

10. Rough-bedded, quartzitic sandstone, forms coping of sharp transverse ridge, 100 to 200 yards south of No. 5.
11. Slope, with obscurely exposed limestone beds.
12. Gray, brown-weathered, fine-grained, gritty deposit, forming crest of prominent bench about 200 yards south of No. 10. Dip 35° to 45° S. W.
13. Gray limestone immediately overlying the preceding gritty bed, with numerous casts of a small Lamellibranch shell, *Pleurophorus?*
14. Unexposed, 100 to 150 yards.
15. Rusty-gray shaly limestone, 15 feet exposed; dip 38°, S. 35° W.
16. Brown arenaceous shales and dark gray limestone, obscurely exposed in slope, 100 yards or more.
17. Dark bluish-gray shaly fragmentary limestone, 20 feet exposed.
18. Unexposed, slope 100 yards or more.
19. Heavy and thin-bedded, gray, rusty brown, buff limestones with shaly grit bands, outcropping in southerly flank of prominent transverse ridge over a space 100 to 150 yards; dip 35°, S. 40° to 45° W. Fossiliferous layers through this deposit from base to top, the forms being the same throughout. These consist of, at least, two species, one a medium-sized *Aviculopecten*, and the other appears to be referable to *Pseudomonotis*, the former occurring in abundance, but their state of preservation is less perfect than could be desired.
20. Southerly slope into dip sag, 200 to 400 yards, partly over the upper shaly limestone layers of the preceding bed.
21. Red shales and arenaceous deposits, more or less clearly exposed in steep ascent rising into the main crest, 1,000 to 1,500 yards north of the outlying ridge at bed No. 19. In the crest the tilted edge of a heavy ledge of red sandstone appears, dipping conformably with the underlying deposits, southwestward.

The ridge last mentioned under No. 21 of the above section attains an elevation of 2,200 feet above the Snake, or an actual altitude of 7,600 feet. The "red beds" of which it is composed are seen to reach an enormous development in the ridges lying to the south-southeast in the direction of Station XXV, four miles distant. From the latter locality, and probably higher position in the series, Mr. Kübel kindly brought in specimens of dark red, even, thin-bedded sandstone, which he reported as occurring in heavy ledges in the summit and along the crest of the front spur, where they also dip off to the southwest. The lower horizons of the section furnish typical exhibitions of the Carboniferous limestone series, but that part which is of most interest is included in the limestone series Nos. 13 to 19. These deposits reach a thickness of several hundred feet, and might even attract the attention from the dissimilarity in their lithology as compared with the inferior limestones and siliceous horizons. But the fossils contained in these upper limestones, though apparently few in species, offer, both in their specific affinities if not identity, and their abundant prevalence in individual numbers, so striking resemblance to the Permo-Carboniferous of other regions as to leave little room to doubt that they represent the latest epoch of the Upper Carboniferous period in this quarter. In regard to the red arenaceous deposits and sandstones, which are apparently conformably superimposed on the latter beds, their identity with the Triassic "red-bed" series is conclusively proven both by their lithology and relative position. The great development of these deposits in the vicinity of Station XXV contrasts with their probable much less vertical extent in the belt outlying Station XXIV, 10 miles to the northwest, though this may prove to be more apparent than real. Yet it may be that the red sandstones in

Station XXV pertain to horizons included in the Jurassic, the resemblance of which to the Trias "red beds" is very marked and liable to deceive. It is not improbable the lower ledge of limestone arches over an anticlinal fold the axis of which lies a little to the northeast of the exposure in the space at present overflowed by the volcanic rocks. But the data are insufficient to more than suggest such a state of things.

Opposite Station XXV the Snake Valley changes its course, curving round due southeast, ascending, which direction it holds to the confluence of Pyramid Creek, and between those points the volcanic flows reach up on the foot of the range several hundred feet above the river-level. In connection with their general southeasterly strike, the bend of the valley brings the "red-bed" series to the front of the range before reaching the Pyramid, where they dip into the mountain, southerly. The Pyramid is a high conical trachytic hill, outlying the mountain-side, and standing almost isolated in the valley, which is here contracted and filled with low hills for a few miles intervening between the lower and upper basins. Pyramid Creek debouches into a basin area, hemmed on the west by the steep red sandstone hills, and on the opposite side by the continuation of the same deposits and an outlying tongue of low wooded hills which projects from the foot of the mountain nearly to the river-side above a mile distant to the northeast. Looking up the cañon, which begins about three miles above the mouth of the creek, red beds alone form the conspicuous strata discernible. But in making the ascent of the main front ridge of the mountain, on the height of which Station XXVI was established, members of other important formations are met with, and on gaining the summit we have also mounted in the geological scale to the horizon of the Jurassic. The section follows a course from the Snake Valley west of south a distance of four or five miles, and although over wide belts in the lower slopes, few details are revealed, due, probably, in part at least, to the position of the strata, and partly to the wooded condition of the slopes, the upper horizons afforded an interesting and better exposed set of deposits for study.

Section through Station XXVI ridge.

1. Dark red rock *débris*, appearing here and there in wooded ridge, close by the margin of the river.
2. Gray and drab limestones, obscure.
3. Gray, flesh-tinted quartzite conglomerate, bedding very indistinct, at one place inclining W. 15° S. at an angle of 40°. It forms a heavy ledge outcropping in the crest of the low ridge on the northeast side of the trail saddle, connecting this outlying group of low hills with the mountain. In other places the ledge seems to dip northeastward, at a less steep angle of inclination, and again it dips west at an angle of 48°; but the first mentioned observation is probably nearer correct.
4. Hard, spar-seamed, bluish limestone, bedding almost or quite obsolete, but appearing as a heavy ledge plating the southwest slope descending into the saddle depression.
5. Obscure traces of red shales, staining the soil red in the saddle (over which the trail passes leading up this side of the valley), and reaching up on the mountain foot. Bluish brecciated limestone fragments are scattered over the surface.
6. In a break in the wooded slope, 500 to 800 yards above the trail saddle, *débris* of gray spar-seamed limestone appears, indicating the presence of a heavy subjacent ledge.
7. A few hundred yards above the last, an obscure ledge of hard red

sandstone outcrops in a low ridge at an elevation of about 1,200 feet above the river.

8. A few hundred yards above the preceding bed, and perhaps one and a quarter miles distant from the trail, a heavy deposit of gray, spar-seamed, gritty limestone outcrops over a considerable belt in a rocky point, accompanied by drab, indurated, calcareous shales, the ledges dipping southwestward.

9. Succeeding the last ledge is a space several hundred yards across, in which frequent exposures of red arenaceous shales and red sandstones appear, though imperfectly exposed.

10. A thin bed of drab limestone.

11. Space several hundred yards across, with exposures of red and chocolate-colored shales below, red shales above, immediately underlying—

12. Red sandstone, dipping southeastward at an angle of 30°, forms crest of prominent point about two and a half miles from the saddle.

13. A belt perhaps half a mile in width, in which no rock exposures were observed, intervenes between the last exposure and the second prominence north of Station XXVI. The latter point is some 200 feet lower than the station, or 8,200 feet above sea-level. It is crowned by a heavy deposit, consisting of alternations of drab-gray fragmentary limestone and indurated shaly calcareous deposits; dip 30° to 50° southward. The lithological characters of this horizon bear intimate comparison with the bed described under No. 8. The limestone contains columns of *Pentacrinus*, and an imperfect shell probably referable to *Aviculopecten*. A rusty dark limestone, exposed in the south flank of the same ridge, affords two forms of Lamellibranch shells, preserved as casts, which may be compared with *Pholodomya* and *Tancredia*, species of which genera were described by Messrs. Meek and Hayden from lower Jurassic horizons in the Black Hills region of Dakota.

14. Thin-bedded sandstone and red arenaceous shales, passing up into drab, nodular, indurated calcareous shales, and red shales above, making a thickness of several hundred feet. The two latter beds, each 100 feet or more in thickness, are best seen in the northeast flank of Station XXVI; also in the amphitheatre west of the first high point a mile north of the station, where the whole series may be seen at a glance, but so cut up by deep ravines as to greatly enhance the difficulty of estimating their thickness even approximately.

15. Heavy ledge of cross-bedded, reddish-gray, chocolate-brown weathered sandstone, with heavy-bedded conglomeritic layers. This rock outcrops in the summit of the high point one mile north of XXVI, where it sweeps down in the west flank, forming the coping of the walls of the amphitheatre which opens into the cañon of Pyramid Creek. It also occurs in the east flank at Station XXVI, where the remaining stratigraphic elements of the section were observed. The dip of the ledge is about the same at either locality, or 35° south.

16. Red arenaceous shales, 10 to 20 feet.

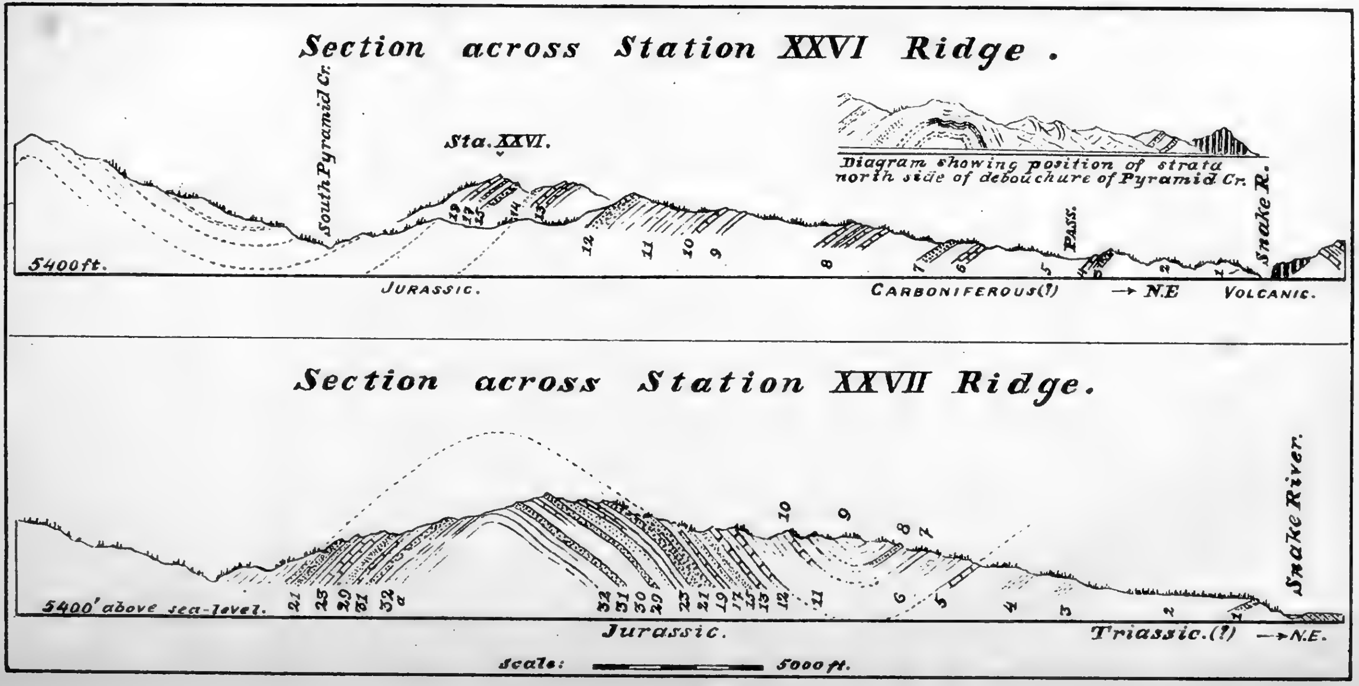
17. Chocolate-red and grayish sandstones, cross-bedded and beautifully laminated, forming a thick bed; dip, locally, 25° south.

18. Deep red arenaceous shales, above pink indurated calcareous shales, exposed in slope 75 to 100 yards across.

19. Dark and light drab, fine-grained, brittle limestone, heavy ledge in summit at Station XXVI. Dip 35° southwestward. Contains numerous individuals of a small undetermined Gasteropod, *Viviparus*?

The upper beds of the foregoing section are clearly Jurassic, and it is scarcely less probable the "red beds" of the Trias hold their proper posi-

PLATE XXIV.



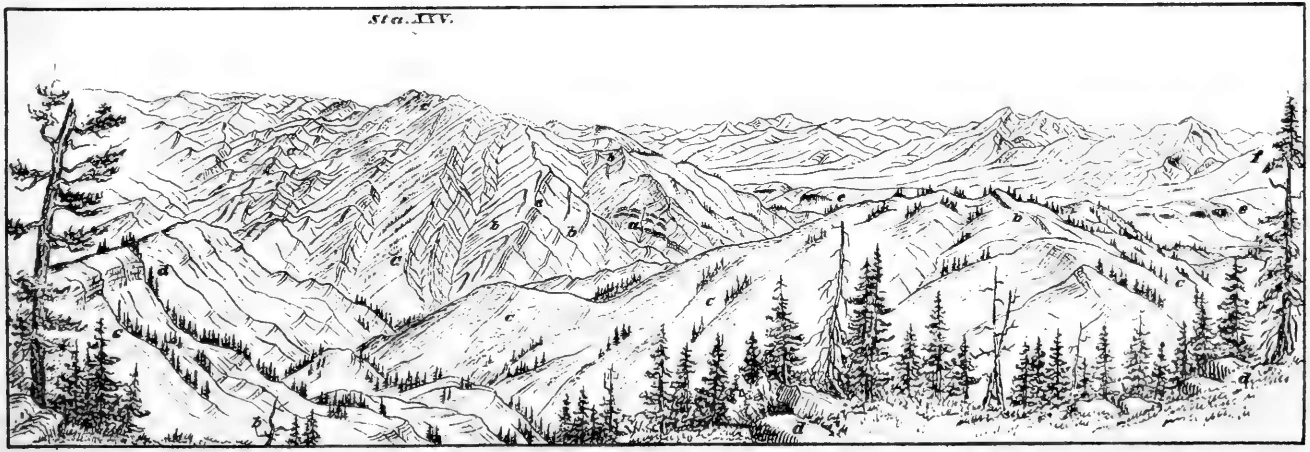
Section across Station XXVI Ridge.
South Pyramid Cr.
Sta. XXVI.
Diagram showing position of strata north side of debouchure of Pyramid Cr.
Pass.
Snake R.
5400 ft.
Jurassic.
Carboniferous (?)
→ N.E
Volcanic.
Section across Station XXVII Ridge.
Snake River.
5400' above sea-level.
Jurassic.
Triassic. (?)
→ N.E.
Scale: 5000 ft.

tion in the imperfectly exposed belt to the north. But still farther in that direction, in the lower slopes, widish belts of alternating heavy limestone and red shales and sandstone deposits occur, the equivalents of which are less satisfactorily demonstrable, although they recall the alternations of calcareous and siliceous deposits elsewhere so characteristic of the Upper Carboniferous. These deposits are probably further complicated by their proximity to a much disturbed belt which lies close along the northeast border of the range in this vicinity. Station XXVI ridge holds the same relative position between Pyramid and McCoy Creeks as that of XXV below the cañon of the former stream; that is, the abrupt front barrier along the Snake Valley. From the back of the northeast spur, along which the above section passes, at the point capped by the red sandstone No. 12, looking to the westward, in the rugged, much-cut-up northwest slopes of Pyramid Creek Cañon, a short distance above or just within the debouchure, the strata exhibit an interesting fold, a rough sketch of which is introduced in an accompanying plate. The nucleus of the fold shows light-gray deposits, probably limestone, undulating or crumpled along the crest of the arch, and pitching sharply on either flank, where, however, they are less distinctly traced. To the northeast of the latter locality a much-disturbed narrow belt, in which the strata are apparently tilted almost vertical, or with steep southerly dip, is followed by northeasterly-dipping red deposits, which, however, in the steep slopes in the west side of the debouchure and lower down in the vicinity of the Pyramid, are observed to incline in the opposite direction, southwestwardly. Above this fold, southwest, succeed heavy deposits of red shales and sandstones, including light-drab calcareous deposits, which continue up the cañon and rise into the rugged monoclinal crest of Station XXV ridge, dipping southwestward. The same series also occurs on the southeast side of the cañon, reaching well up into Jurassic horizons, the strike trending from a southeast round more to an east course in this latter quarter. The stratigraphic display, as seen from the high point a mile north of Station XXVI, is of exceeding interest. At a glance it shows the great monoclinal ridge of Station XXV, the superstructure of which is built entirely of the rich-toned materials of the Jura-Trias, and apparently based upon a much disturbed foundation of Upper Palæozoic rocks. North of the latter station mention was made of the probable existence of a fold in the Carboniferous beds in the foot of the mountain bordering the valley. It is barely possible that the latter fold has some intimate, even direct, connection with the similar disturbed belt within the debouchure of Pyramid Creek above noticed. Yet this is not quite certain. In the former quarter erosion and subsequent volcanic eruptions have destroyed and concealed the outlying northeast flank of the fold, so that the means are wanting for a more critical comparison of the phenomena in that quarter with the apparent greatly-disturbed corresponding belt in the mouth of Pyramid Creek Cañon. The lower limestone deposits of the above section, including also the limestone and quartzite in the low ridge to the northeast of the saddle over which the trail passes, may with a degree of warrant be provisionally referred to the Carboniferous. But the latter exposures occur quite beyond or outside the above-mentioned uplift, and probably belong to the southwest flank of a fold the axis of which may lie in the mountains on the opposite side, or within the area of the Snake Valley. The strata are pitched headlong into the intervening synclinal, and much pinched, as indicated by their highly-tilted position in opposite directions in the section more or less well-displayed in the entrance to Pyramid Creek Cañon.

Station XXVI, which attains an altitude of about 8,400 feet, commands the whole of the upper basin of the lower valley of the Snake, the rugged barrier of the Snake River Mountains, and a wide belt of the Caribou Range, embracing the summits between Fall Creek on the northwest and Tin-Cup Creek to the southeast, with the loftier portions of the range in view. Four miles to the west the view is shut out by a still higher mountain crest, only second in elevation to Mount Caribou, or 9,600 feet above the sea, and which occupies the axis of an anticlinal fold. The side toward the east shows great plates of red deposits, which contrasted beautifully with the snow cornice stretched along the brow, and the deep green of the fir-clad lower intermediate ridges. The mountains are sharply and cleanly sculptured; there are few rounded or indistinct lines in their contour, and none of those jagged outlines such as archæan and sometimes volcanic rocks often impart to mountain topography. The ravines and northeast slopes of the mountain ridges are generally clothed in coniferous forests and undergrowth, giving to the whole aspect of the abrupt mountain front, as seen from the valley, a densely wooded appearance. The depression between Station XXVI and the culminating crest of this block of the range to the west marks the position of a sharp synclinal fold, from which the strata more gradually rise up into the crest of the ridge at the station, and where they have the appearance of flattening out in a broad-topped arch. This may indeed prove to be the roof of the fold, before described, in the lower part of Pyramid Creek Cañon. Even from the necessarily meagre data obtained in so hasty a visit, it seems almost certain that, while the axes of elevation hold a general and uniform course throughout the range, but which erosion has thrown into a relative position more or less oblique to the general direction of the range, the folds exhibit in their minor or local manifestations great diversity both in course and magnitude, so that their characteristics are subject to greater or less change within short distances, and tending greatly to increase the labor requisite for the thorough elucidation of the geologic features of the whole range.

Ascending the valley in a south-southeast direction, the mountain presents an exceedingly steep front, cut by numerous little streams which debouch from picturesque cañons, whose mouths are usually filled with accumulations of *débris* brought down by torrents. At a place some four miles above Pyramid Creek the steep mountain-side shows heavy deposits of red shales and sandstones dipping southwestward into the mountain. These beds continue several miles, until reaching an extensive tract of beaver-swamps, perhaps midway between Pyramid and McCoy Creeks, just above which in the southeast angle of the debouchure of a little cañon, where the river approaches close to the mountain-side, similar rusty-red deposits appear, steeply inclined northeastward. It is presumed that this locality marks the axis of the pinched synclinal fold already remarked in the lower part of Pyramid Creek Cañon; at all events, the strike of the strata at the latter locality would cause them to appear in the valley-side at about this point. These deposits thence continue in the steep slope, with frequent interruption in the continuity of their outcrop, to a point two or three miles below McCoy Creek. Here, in a low point in the west angle of a recess in the hills, heavy ledges of dark, dull red, fragmentary, thin-bedded sandstone, banded with lighter shades of color, appear in low mural exposures, dipping southward at an angle of 25°. The same deposits also appear in the low ridges and bed of McCoy Creek where its valley opens into that of the Snake, and where they dip southwestward at the same moderate angle. Above the latter point a high bench of the mountain borders

PLATE XXV.



Caribou Range: Pyramid Cañon from Sta. XXVI ridge, looking N.N.W. Jura-Trias.

a. Limestone arch. b. Drab shales and limestone. c. Red sandstones and shales. d. Conglomerate, etc. e. Volcanic benches Snake Valley. f. Snake River Range.

this side of the valley, the foot of which is closely skirted by the river as far as the confluence of Salt River, two and a half miles, in which only obscure exhibitions of similar beds are to be detected for the dense forests that prevail in this quarter. To the south of this, the range passes beyond the limits of our district, gradually diminishing in altitude and in transverse dimension, its east side bounded by the broad valley-plain of Salt River.

In making the ascent of the front ridge belonging to the block embraced between McCoy and Tin-Cup Creeks, the way lay across this high bench for about a mile, when the steeper slopes are reached at an elevation of 700 to 800 feet above the river. Thence the slope is steeper and more broken to the culminating crest, which bears a little west of north and east of south, the strike of the strata wavering along the crest of the main ridge. Hence, in passing from the north to the southward, different beds are found to constitute the protecting caps in the high points, on one of which Station XXVII was located at an elevation of 3,520 feet above the valley. The following section, extending southwestward from the confluence of Salt River to the crest of Station XXVII ridge, a distance of about four miles, shows the stratigraphic structure of this part of the range.

Section through Station XXVII ridge.

1. Dark brownish-red conglomeritic sandstone, evidently a heavy bed outcropping in brow of high bench 500 feet above Snake River; dip southward.
2. Long, gentle slope, densely wooded and interspersed with beautiful grassy glades; no rock exposures observed.
3. Reddish-brown arenaceous *debris*, mixed with the soil in steep ascent.
4. Red shales and red sandstone *débris*.
5. Limestone *débris*.
6. Drab shales.
7. Red shales and red sandstone fragments.
8. Gray, reddish stained sandstone, a heavy bed outcropping in rocky bench facing the valley two miles distant; dip 36°, S. 55° W.
9. Gentle ascent, half a mile or so across, with exposures of chocolate-red shales and reddish-gray sandstone.
10. Dark drab fragmentary limestone, a thickness of 20 feet exposed in rocky ridge, underlaid by dark drab shales including thin layers of limestone. Dip 54°, N. 65° E.
11. Red shales.
12. Drab, spar-seamed limestone, with some chert. Dip 55°, N. 60° E.
13. Drab limestone, similar to preceding beds, 20 feet exposed; dip 50°, N. 65° E.
14. Drab shales, 10 feet, underlaid by red and chocolate-colored shales, 35 feet.
15. Red sandstone, 10 feet.
16. Red and chocolate-colored shales, 50 feet.
17. Reddish gray and brown sandstone, interbedded with dark reddish-brown shales.
18. Nodular limestone.
19. Dark gray laminated sandstone, 15 feet exposed; dip 50°, N. 55° E.
20. Brick-red shales, 50 yards across.
21. Dark reddish-brown, beautifully laminated and false bedded, hardish sandstone, interbedded with heavy layers of reddish-brown con-

glomerate, forms a heavy deposit several hundred yards across, flagging a prominent outlying ridge; dip 35° to 45°, N. 55° E.

22. Red and chocolate-colored shales, 50 to 100 yards across.

23. Drab, fragmentary limestone, forming a heavy bed; dip 28°, N. 45° E. Contains a small Gasteropod, too imperfect for determination.

24. Chocolate-colored and red shales, 50 to 100 yards.

25. Reddish-brown, laminated sandstone, 40 feet exposed.

26. Reddish shales, space 50 yards across.

27. Reddish sandstone, similar to bed No. 25, 10 feet exposed.

28. Chocolate-colored shales, in steep slope, 50 to 100 yards.

29. Redish brown and gray, obliquely-laminated sandstone, a heavy ledge 25 yards across the exposure, at one place a mile north of Station XXVIII, forming crest of main ridge; dip 20° to 35°, E. 15° S. to E. 30° N. This probably belongs to the preceding overlying beds 25 and 27, which together make up a thick deposit, including the red and chocolate shales 26 and 28.

30. Chocolate-colored shales, including a layer of hard, bluish-gray, gritty limestone, with *Belemnites densus*, and dark-brown sandstone layers. Exposed in slope west side of crest a mile north of Station XXVII, and 100 yards or more across.

31. Heavy ledge of conglomerate and dark, reddish-brown laminated sandstone, 20 feet exposed; dip 25°, N. 40° E.

32. Steep *debris*-covered slope, 300 yards or more across, showing reddish shales and reddish sandstones, with harder layers of dirty gray sandstone in lower portion of slope, where the dip is southwestward at an angle of 40°. In the lower portion of the slope a thin, dirty, gritty band occurs, which is charged with a pretty little *Gryphæa* (?) characterized by a few strong radiating plications; there are, besides, fragments of *Ostrea strigulecula* and *Lingula*.

31*a*. Heavy ledge, made up of gray sandstone, dark conglomerate, and dark, reddish-brown laminated sandstone, arranged the order mentioned, but imperfectly exposed; dip 35°, S. 45° W.

30*a*. Unexposed space.

29*a*. Reddish-brown, laminated, hard sandstone, imperfectly seen.

28*a*. Red shales.

27*a*–25*a*. Reddish-brown sandstone, obscure exposure.

24*a*. Red shales.

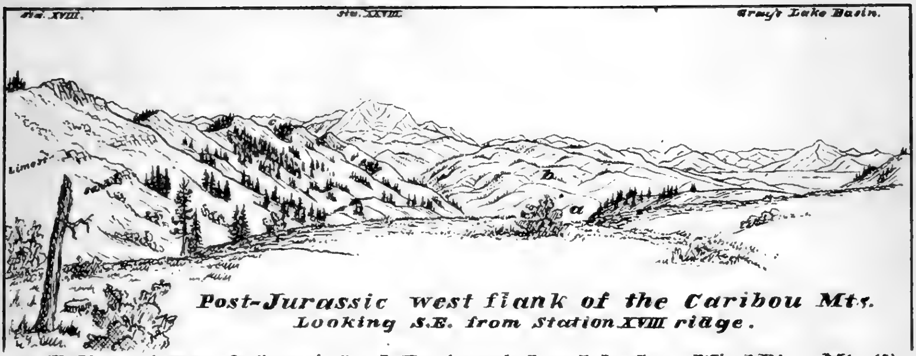
23*a*. Fragmentary limestone, 10 to 15 feet exposed, overlaid by light drab shaly limestone and indurated calcareous shales, apparently forming a heavy bed, 100 yards across the exposure.

22*a*. Red shales.

21*a*. Heavy ledge dark, reddish-brown sandstone and conglomerate, dip southwestward, the angle of inclination steepening as the ledge passes down into a deep lateral ravine communicating with McCoy Creek Valley.

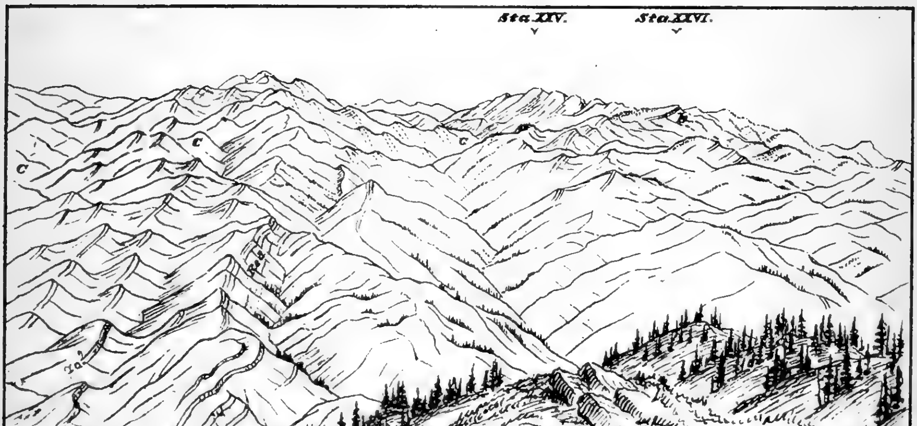
Station XXVII ridge extends above three miles in a direction a little east of south, its summit preserving quite uniform heights 8,800 to 9,000 feet above sea-level. The individual peaks all show monoclinal structure, but the mass of the ridge is built upon an anticlinal fold whose axis apparently lies along the west flank as far south as the station, curving in and out in its course, the conglomerate cap, No. 31, at the latter point belonging to the east flank of the uplift, the same as at the point where the foregoing section crosses the ridge a mile to the northward, where, however, this stratum appears in the west slope and arching over, as shown in the accompanying diagram. The strata exposed in this fold pertain to the Jurassic, and besides the general interest of this part of

PLATE XXVI.



Post-Jurassic west flank of the Caribou Mts.
Looking S.E. from Station XVIII ridge.

a. Valley of E. Fork Gray's Cr. b. Variegated red beds. c. Wind River Mts. (?)



Caribou Range: From Station XXVII ridge, looking N.W.

a. McCoy Creek Valley. b. Jura. c. Variegated Post-Jura.

the section it also possesses much additional interest in the perhaps more or less local stratigraphic details here displayed and the fauna observed in connection with some of the beds. It would appear that the greater portion of the outlying eastern flank, in which a well-defined synclinal fold exists, also is occupied by beds of Jurassic age. But in the border of this slope, in the area of the foreland bench, it may be possible the sandstones and arenaceous shales of the Triassic "red-bed" series make their appearance in the regular descending order of their stratigraphic sequence, although their identity is open to question.

From the summit the topographic and stratigraphic relations of this mountain ridge are well displayed. It is stratigraphically identical with the high dominating ridge west of Station XXVI, and almost due northwest of the present station, the crest of the anticlinal being traced almost continuously between the two points, though it is broken through by the valley of McCoy Creek in the foreground. To the northeast of this fold in the strata the synclinal depression shown in the foregoing section also has its counterpart in the depression between the dominating ridge and Station XXVI, the beds curving up in a broader, flat-topped arch in the latter station. The sketch introduced in an accompanying plate will convey a clearer idea of the features here alluded to. The broken and more wooded eastern slopes exhibit less satisfactorily the stratigraphy and structural features, though in the declivities on the lower course of the valley of McCoy Creek the beds show moderate southwesterly inclination which continues to the debouchure. It seems almost certain that these formations in the region on and south of Pyramid Creek, in the vicinity of XXVI, have been bulged up into a broad low dome of very irregular contour, the exact extent of which it is difficult to define. But as no appearance of such a fold exists in the exposure on McCoy Creek, it is probably confined to a belt, the middle of which lies near the debouchure of Pyramid Creek cañon, extending north and south from points within or but little extended beyond the limits of Stations XXV and XXVI. The northeastern border of this uplift, as has already been remarked, includes a narrow zone of greatly disturbed and complicated strata along the border of the mountains, which runs out into the Snake Valley before reaching McCoy Creek. This zone may extend north as far as Fall Creek though it is thought more probable that it ceases soon after passing Pyramid Creek, to the north of which the flow of volcanic materials has concealed what the erosion of the valley left untouched. Looking westward, stretches of McCoy Creek may be seen, and in the north side-hills there occurs a fine display of a broad, low, anticlinal fold, flanked at the entrance to the upper basin by an extraordinary uplift and partial overthrow which will receive fuller notice in the description of the McCoy Creek section. This broad fold is indicated by wide areas of comparatively gentle drainage slopes in the broad ridge intervening between Station XXVII and Mount Caribou (XXVIII) nine miles to the westward, south of which, owing to the wooded nature of the low mountains in that quarter, nothing was clearly made out in regard to its further extension and character. But in the low southern prolongation of the range, patches of red appear in the steeper slopes, doubtless showing the prevalence in that section of the same series of strata which fills the space between the above-mentioned stations. To the north round into the southeast the great barrier front of the Snake River Range walls the lower valley of the Snake and Salt Rivers, the southwest slopes supported by short rocky buttresses and scantily wooded. Here and there the view penetrates into the heart of the mountains, where high summits and ridges with

enormous exposures of red and gray strata appear. To the northeast opens the grand cañon, a narrow defile bounded by steep slopes and mountain escarpments composed of the magnificent exposure of Carboniferous rocks described by Bradley. Far away a line of snowy peaks points out the course of the Wind River Range; but grandest of all are the Tétons, whose great bare peaks rise like gigantic monoliths from a broad mountain summit which even at this late season, July, had not yet put off its winter raiment.

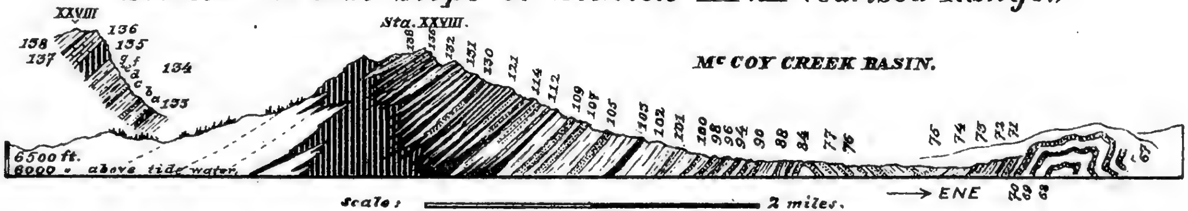
We had been so long employed in breaking our own trails that it was with a curious mixture of relief and positive pleasure we entered the trail leading up the valley of McCoy Creek, crossing and recrossing the rapid stream, now passing over pretty intervals, then along the face of some jutting spur, until it finally emerges into the upper basin in which this drainage is gathered. This little valley has a general course a little north of east and south of west, with but one sharp curve near the middle, where it passes the lower narrow anticlinal fold descending from Station XXVII. It can hardly with propriety be termed a cañon, although at a few points it is confined within narrow bounds by the near approach of the bordering hills; but it generally possesses a narrow intervale, and at few places are the hills precipitous, though the country is very rough and broken on either side. The stream is bordered by willows, and in places ponded by beaver-dams, and would be beautiful were its waters uncontaminated with the sediments from the placer mines at its head. The fall of the stream in the ten miles between the mountain basin and its mouth is about 630 feet. The basin in which the waters from numerous sources are collected is the largest of the mountain basins in the range, and is separated from the basin of John Gray's Lake by a narrow ridge of hills; the surface is undulating and broken by spurs, and though its altitude may be too great for successful agriculture, it is a valuable grazing region.

The sources of McCoy Creek rise in the two principal mountain elevations of the range, that to the north being the same as the massive mountain whose crest lies on the axis of the Station XXVII anticlinal, and which is only two or three hundred feet lower than Mount Caribou on the south, which attains an altitude of 9,800 feet above the sea. This mountain, which was chosen for Station XXVIII and which was also made a station of the primary triangulation by Mr. Wilson, presents an imposing appearance from whatever direction it is viewed, and it proved to be a most interesting locality geologically. Its summit forms an irregular, shelving, flattened space. from which radiate three principal spurs, of which the southern is the largest and at one point rises into a dome but little inferior in elevation to the main summit. The two other spurs project respectively westward and north, inclosing the depression or recess which bears so striking resemblance to a huge crater whose northwest wall has been demolished, as seen from that direction. Besides these, there are several large secondary spurs, the disposition of which is an interesting topographic feature of the mountain. They form rugged ridges in the easterly face of the mountain, environing at their heads little Alpine amphitheatres in some of which nestle tiny lakelets, dammed by accumulations of *débris* through which their waters percolate and form the spring sources of Iowa Gulch, one of the main tributaries of McCoy Creek. The slopes on the west are much more uniform, a broad gulch penetrating this side between the main crest and that of the south spur. To the southwestward the mountain descends to a lower ridge, which extends in that direction into the adjacent district, defining the wide drainage belt flowing eastward into

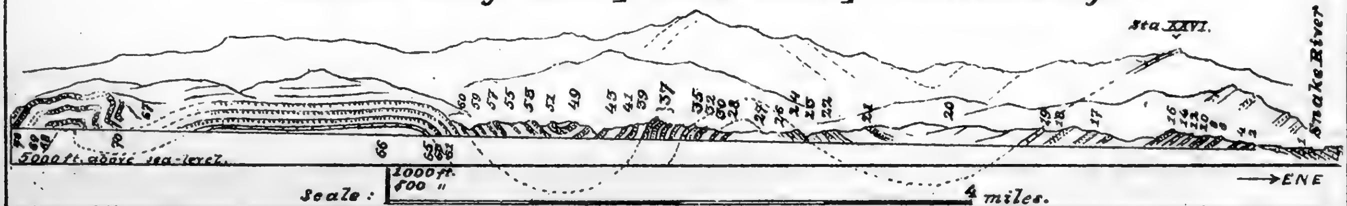
PLATE XXVII.

Section in west flank of the Caribou Range, south of Station XXVIII.

Section in east slope of Station XXVIII (Caribou Range.)



Section along Mc Coy Creek Valley (Caribou Range.)



Salt River from the far less important western drainage. A similar but lower ridge projects in the opposite direction, forming the before-mentioned divide between McCoy Creek and John Gray's Lake. The mountain flanks are well wooded with coniferous forests, and lovely little meadows are encountered in unexpected places between the lower and more rounded outlying ridges on the west side. The summit commands nearly the whole of the southwestern section of the district, besides the extensive basin region to the southward. The country lying westward appears surprisingly flat, notwithstanding we found it diversified by sufficiently rugged low mountain ridges, broad basin plains, and cañoned water-courses. The Snake River is hidden in the deep trough of its lower valley, but to the southeast, overlooking the comparatively low intervening mountain belt, its southerly continuation opens out in the broad basin of Salt River, which like all these basin areas is covered by extensive tracts of marsh, whose willow copses give the not uncommon effect of cloud-shadows resting on the extensive levels.

In the valley course of McCoy Creek a magnificent section, reaching three-fourths the way across the range, is displayed, the study of which, notwithstanding the limited time at our disposal, resulted in the securing of data from which it is possible to gain an approximately accurate knowledge of the structure of this portion of the range. As the examinations were continued completely across the range, *via* Iowa Gulch and Mount Bainbridge, to the plain of John Gray's Lake on the southwest border, in collating all these data the section has been located along a direct line bearing about E. 35° N. and W. 35° S., intersecting Mount Caribou the western portion of the valley of McCoy Creek, along which the observations were made, lying a little north of the line of the section, the lower or northeast portion of which closely corresponds with the direction of that part of the valley—the profile making no pretence at showing the actual surface contour, being merely a partially ideal adaptation to facilitate the illustration of stratigraphic and structural features. The section in which are incorporated such details as were noted in a hasty examination, is shown in an accompanying plate, and exhibits the following stratigraphic elements, commencing at the debouchure of McCoy Creek into the lower valley of the Snake, and proceeding thence southwestward across the range:

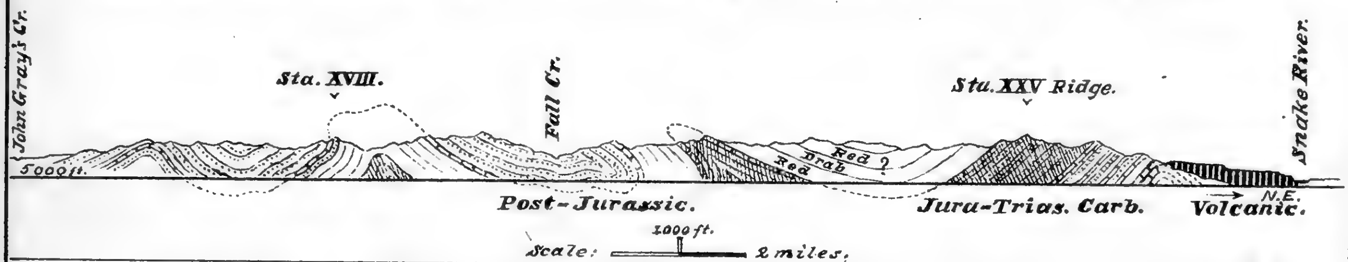
Section across the Caribou Range, via McCoy Creek.

1. Variegated soft arenaceous clays of Tertiary age, resting on the upturned edges of the older strata, and dipping northeastward at angles of 25° to 40°. These deposits occur in the valley of the Snake and Salt Rivers, and will be further noticed in the section devoted to the lower valley of the Snake.
2. Deep-red sandstone, dipping southwestward at a moderate angle of inclination.
3. Obscure exposure of light-drab deposits.
4. Red sandstone ledge forms a low fall in the bed of the creek at its debouchure.
5. Red shales and indurated arenaceous layers, forming a heavy bed.
6. Light-red sandstone, 30 feet exposed.
7. Red shales, pale red above, 100 to 200 feet.
8. Red sandstone.
9. Chocolate-colored shales.
10. Red sandstone, deep red thin-bedded below, 50 feet exposed.
11. Red shales.

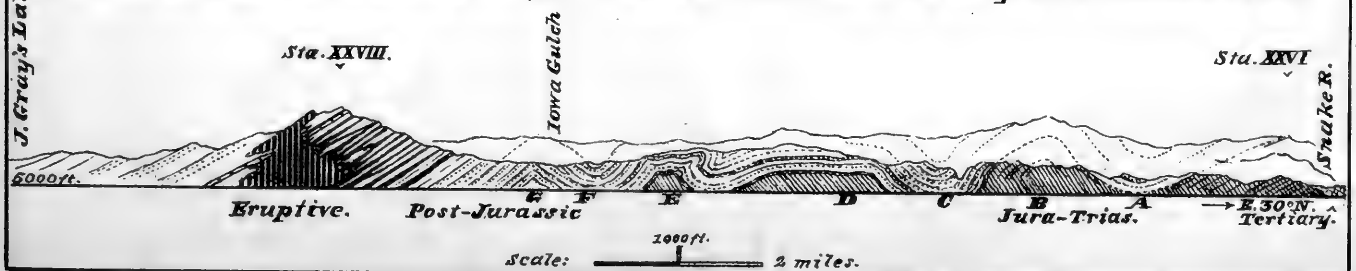
12. Drab limestone, 20 feet exposed, overlaid by light-drab, indurated calcareous shales.
13. Red shales, obscure exposure.
14. Light shaly calcareous deposits.
15. Chocolate-colored shales, 200 feet, more or less.
16. Dark brownish-gray, obliquely laminated sandstone, a heavy ledge.
17. Chocolate-colored shales, including thin bands of dark-red sandstone, obscurely exposed in low undulating hillside, several hundred yards across.
18. Drab and chocolate-colored shales, obscure exposure.
19. Dark-blue spar-seamed limestone, obscure ledge, may not be *in situ.*
20. Wide space occupied by undulating grassy slopes, with no rock exposures.
21. Brown sandstone, obscure exposure; dip gently northeastward.
22. Chocolate-colored shales below.
23. Chocolate-red and hard drab beds; dip at an angle of about 40° northeastward.
24. Heavy bed spar-seamed gray limestone, with rotten chert; dip about 30° northeastward.
25. Chocolate-colored and red shales.
26. Limestone, similar to bed No. 24, 50 to 100 feet exposed.
27. Wide space, showing no rock exposures.
28. Brownish sandstone, obscure exposure, ten yards across; dip southwestward.
29. Light and chocolate-colored shales below, light shales above.
30. Drab limestone.
31. Red sandstone and red shales; dark chocolate-colored and drab shales above.
32. Heavy ledge brown laminated conglomeritic sandstone, dip southwestward at an angle of about 25°.
33. Unexposed space.
34. Gray sandstone.
35. Drab-gray limestone.
36. Space showing obscure exposures of sandstone.
37. Dark rusty red conglomeritic sandstone ledges, interbedded with shales. These ledges exhibit an interesting exposure in the precipitous walls on the south side of the stream at the narrows just above the debouchure of a considerable tributary draining the west flank of Station XXVII ridge, the beds appearing nearly vertical and arching over to the northeastward.
38. Unexposed space.
39. Sandstone.
40. Red shales and sandstone.
41. Sandstone, dipping southward.
42. Red and chocolate-colored shales.
43. Gray sandstone, 20 feet imperfectly exposed.
44. Red and chocolate-colored shales.
45. Chocolate-brown thin-bedded sandstone, 10 feet exposed.
46. Chocolate-colored shales.
47. Reddish buff or gray sandstone.
48. Reddish shales.
49. Reddish-gray sandstone; dip northeastward.
50. Chocolate-colored shales.
51. Brownish gray sandstone; dip northeastward.

PLATE XXVIII.

Ideal Section across the Caribou Range, south of Fall Creek Cañon.



Section across the Caribou Range, via Mc Coy Creek Valley and Station XXVIII.



52. Chocolate-colored shales with indurated arenaceous layers, obscurely exposed.
53. Chocolate-brown and gray shaly sandstone.
54. Chocolate-drab shales and sandstone.
55. Gray sandstone.
56. Unexposed space.
57. Brownish-gray, laminated, thin-bedded sandstone, 25 feet exposed. Dip steeply northeastward.
58. Red shales.
59. Sandstone ledges, interbedded with chocolate-red shales, forming a heavy deposit; dip northeastward at an angle of 45°.
60. Dark drab shales, with two or more ledges of rusty reddish-gray sandstone, a heavy deposit several hundred yards across.
61. Brownish sandstone.
62. Red shales.
63. Reddish sandstone.
64. Red shales.
65. Drab limestone and light-drab indurated calcareous shales, exposed many hundred yards, nearly horizontal or gently undulating, overlaid by beds 64–61, conformably.
66. Pale-red shales.
67. Wide space in which the continuity of the strata is interrupted. But the limestone No. 65 and superimposed beds gently descend in passing up the valley, and it seems probable that they form a sag or synclinal east of the abrupt displacement which shows deposits that agree quite closely with the lithology of the sandstone appearing in the upper part of the broad, flattened uplift with which their identity is inferred with a degree of probability.
68. Reddish sandstones and shales, obscurely seen in the axis of the displaced beds, and may be the equivalents of Nos. 61 and 62.
69. Dark-drab shales.
70. Reddish-brown weathered sandstone; a heavy ledge, which on the east is suddenly uplifted into a position past the vertical, the western exposure protruding in the steep valley-side, dike-like, and inclined southwestward at angles of 75° to 80°. These two masses are seen to be connected by an undulating arch of sandstone, gently inclined to the westward, the angles of sudden flexure exhibiting unmistakable evidence of the intensity of the strain to which the beds were subjected, in the broken and confused condition of the layers at those points. There are apparently two distinct horizons of the brown-gray sandstone and drab shales included in the uplift, which probably are identical with the upper horizons, Nos. 61, 60, seen in the broad level space to the east.

The valley here opens out into the mountain basin, the stream branching, the main fork continuing west and Iowa Gulch coming from the south; in the intervening upland ridges and along the crest of one of the northeast spurs descending from Mount Caribou the following numbers (71–101) appear:

71. Hard, thin-bedded sandstones, and brown-drab shales, several hundred feet, dip steeply southwestward.
72. Chocolate-colored and red shales, heavy deposit.
73. Gray thin-bedded sandstones and shales.
74. Red shales.
75. Shaly gray sandstone; dip 60°, southwestward.
76. Variegated chocolate-colored, drab-blue, red, and drab shales.

77. Gray spar-seamed sandstone, obscure exposure; dip northeastward.
78. Chocolate-red shales, exposed space 180 feet.
79. Chocolate-gray, thin-bedded sandstone; dip steeply northeastward.
80. Chocolate-red shales, exposed space 120 feet.
81. Gray, thin-bedded, spar-seamed sandstone; dip 38°, N. 55° E.
82. Red shales, exposed space 90 feet.
83. Chocolate-gray sandstone, 10 feet exposed.
84. Gray, thin-bedded, spar-seamed sandstone, exposed 20 feet, thrown up into a sharp arch, on the one hand dipping 35°, N. 20° E., and on the opposite flank 50° to 60°, W. 15° S. Exposed space 75 yards.
85. Unexposed 20 yards.
86. Gray, spar-seamed sandstone, exposed 10 feet; dip very steep southwestward; almost vertical.
87. Imperfectly exposed space, with red, chocolate-colored shales, 180 yards.
88. Gray, thin-bedded sandstone, obscure exposure; dip 72°, S. 65° W.
89. Red and chocolate-colored shales and thin bands of sandstone; exposed space 300 yards.
90. Gray, chocolate-mottled, thin-bedded sandstone; obscure exposure.
91. Chocolate-red shales; exposed space 100 yards.
92. Softish, gray, thin-bedded sandstone, 20 feet exposed; dip 46°, S. 55° W.
93. Blue indurated clay shales, exposed space 100 yards.
94. Gray, reddish-weathered, thin-bedded sandstone.
95. Red shales, exposed space 120 yards.
96. Gray, spar-seamed sandstone, obscure exposure.
97. Red shales, exposed space 100 yards.
98. Brownish-gray, coarse-grained sandstone, exposed 15 feet; dip 45°, S. 65° W.
99. Red arenaceous shales, exposed space 70 yards,
100. Gray, thin-bedded sandstone, obscure exposure; dip 35°, S. 60° W.
101. Drab and red shales, with drab indurated shales, alternating, imperfectly exposed over a space of 500 to 800 yards, up to wooded point of spur on the northwest of Anderson's Gulch.

The section thence was carried from a point on Iowa Gulch near the lower placer mines, where anticlinal fold G again appears, up the great spur between Anderson's Gulch and Bilk's Gulch to the crest of Station XXVIII (Mount Caribou). In this ridge the same series of gray sandstones outcrop as shown above, and which incline southwestward. At a higher point, where the ascent steepens, a heavy ledge of eruptive material makes its appearance, with which the section is continued, as follows:

102. Unexposed space lying between the last above-mentioned deposits, No. 101, and the following:
103. Gray, hornblendic trachyte, with *débris* of similar rock in slope above.
104. Hard, gray sandstone *débris*, not seen *in situ*.
105. Hard, gray sandstone, obscure exposure.
106. Space with red earth and gray sandstone below, red shales above.
107. Gray, thin-bedded sandstone; dip 50° to 60°, S. 65° W.
108. Red earth, indicating subjacent red shales.
109. Gray sandstone; dip steep southwestward.

110. Red earth.

111. Eruptive rock, similar to No. 103; forms a heavy ledge, dipping at a steep angle southwestward.

112. Bluish, spar-seamed limestone, exposed space 20 feet, but much broken up, obliterating the planes of bedding; contains obscure remains of a very small robust or gibbose form of Gasteropod, resembling a form occurring elsewhere in horizons provisionally referred to the Laramie formation; but, at the same time, it is difficult to distinguish it from very similar forms, both in appearance and condition, prevalent in Jurassic strata in the same region.

113. Gray sandstones and red shales, exposed in space perhaps 200 yards across.

114. Eruptive or intrusive porphyritic ledge, like 111, but much broken up; exposure 25 yards across.

115. Gray and drab, partially metamorphosed shales, space 60 yards.

116. Soft gray sandstone, 60 feet exposed; dip 30°, S. 45° W.

117. Red shales, 20 yards across.

118. Eruptive ledge, like 114, much broken up.

119. Gray sandstone and chocolate-colored shales, with porphyritic trachyte *débris* in the surface, and bluish-gray arenaceous indurated or metamorphosed shales above, space 100 to 150 yards; dip 45° southwestward.

120. Eruptive ledge, like 118.

121. Bluish, fine-grained, ripple-marked, indurated arenaceous shales, interbedded with brown chocolate-colored shales, all more or less indurated or metamorphosed, exposed 30 feet, space 100 yards.

122. Eruptive ledge, like 118, 15 feet exposed.

123. Metamorphosed variegated shales, 30 feet exposed.

124. Eruptive intruded ledge, like 122.

125. Bluish, chocolate-colored, laminated slaty shales, much changed by contact with intrusive volcanic material; dip 45° to 50°, S. 45° W.

126. Eruptive ledge, like 124, space 30 yards.

127. Slaty shales and fine-grained bluish gray sandstone, space 30 yards; dip 35°, S. 45° W.

128. Eruptive ledge, like 126, space 15 yards.

129. Brittle drab slates or metamorphosed shales, including below two thin sheets of intrusive volcanic material like 128, space about 200 yards.

130. Dark brownish gray sandstone and conglomerate.

131. Several ledges of eruptive intrusive matter, like 128, exposed high up on spur, the crest of which for several hundred yards is strewn with *débris* of similar rock, with obscure exposures of highly metamorphosed drab and blue-green mottled slaty shales. In the summit of the outlying dome by which the spur attaches to the saddle southeast of the main summit, there appears a ledge of dark bluish hornblendic trachyte, much broken up, so that its character may not be readily determined—whether a dike or intrusive mass—and so with other exposures of these volcanic materials.

On the northwest side of Station XXVIII the mountain is broken down precipitously into a little amphitheatre, half environed by cliffs and talus slopes, in which a section showing a vertical thickness of several hundred feet of sedimentary and intrusive ledges may be advantageously studied. Although the direct connection could not be traced, it is presumed that the volcanic intrusive ledges which appear in the amphitheatre walls are the same as the blindly-exposed ledges last referred to in the upper crest of the spur next southeast, the strike of the

sedimentaries indicating such to be the case. Therefore, with the description of this escarpment exposure, the section is carried to the summit of Mount Caribou, and is as follows:

132. Drab shales, metamorphosed into brittle slates, exposed 50 feet, the base concealed beneath the upper rim of the talus accumulation.

133. A heavy ledge of decomposing greenish gray intrusive rock resembling basalt, enclosing hard pebble-like bodies of hornblendic trachyte; about 25 feet.

134. Drab, green, and chocolate-tinted shales, changed by metamorphic action to a brittle slate, a heavy deposit, in the aggregate about 365 feet, which was deposited consecutively with that portion mentioned under No. 132, from which it was subsequently separated by the intrusion of the volcanic matter No. 133. This deposit presents the following subdivisions: *a.* The lower 75 to 100 feet shows at the bottom and top buff sandstone layers, and distributed through the mass of the slate occur apparently irregular bands or "pockets" of rusty, porous "mineral"-like material, which doubtless owes its origin to volcanic action. *b.* Drab, greenish-tinged metamorphosed shale, about 100 feet; dip 25° to 35°, S. 60° W. *c.* Laminated sandstone, 5 feet exposed, probably thicker, interlaminated with shales. *d.* Irregular lenticular or "pocket"-like masses of brown or rusty gray "mineral" rock included in metamorphosed shale, associated with calcite, distributed through a thickness of about 60 feet. *e.* Thin intrusive sheet of porphyritic (?) rock, 3 feet. *f.* Chocolate-drab, metamorphosed shale, about 60 feet.

135. A heavy deposit, apparently consisting of a brecciated conglomeritic mass caught up in the intrusive material, with green copper-stained pyritous "pockets," and presenting an inferior rusty porous portion, darker purple middle layer, and greenish-tinged upper portion, in the aggregate about 100 feet thick; dip 45° southwestward.

136. Drab and gray, rather uniformly fine textured limestone, apparently partially metamorphosed and fragmentary, exposed 30 to 75 feet. In the saddle to the southeast of the summit, and at a lower level, the ledge dips at an angle of about 30° S., 45° W. It contains a small Gasteropod, but too imperfect for further determination than to note its resemblance and probable specific identity with the but little better preserved specimens of the shell occurring in bed 112. This rock outcrops in the saddle west of, and intervening between, the summit at the station and the slate-capped prominence of the great west spur. It is here much changed by metamorphism, probably by contact with, or proximity to, the eruptive mass of which the bulk of this spur is composed.

137. Greenish gray decomposing ferruginous intrusive mass, resembling rotten basalt, and belonging to a debatable series of volcanic products. About 6 feet.

138. Highly metamorphosed drab, brittle shale, thickness undetermined, crowning the summit and occurring in patches in the shelving western portion of the main mountain.

From the latter point our examinations of the slopes on the western flank, or John Gray's Lake drainage, were carried along a line a couple of miles southeast of Station XXVIII, commencing at the summit of the lower mountain ridge, which constitutes the southeastern prolongation of Mount Caribou. The initial horizons at the latter point were not positively identified with any member of the foregoing section; but, taking into account the bearing of the ledges in Station XXVIII, it seems very probable that the two localities are stratigraphically identi-

cal, or but little separated, the following deposits lying to the westward and conformably superimposed on the preceding. The section concludes with the following and fartherest west-lying deposits occurring in the undulating uplands south of John Gray's Lake and occupying the interval between the southwest base of the Caribou Range and the northeast foot of the narrow ridge which is designated as the "Gray's Lake ridge" in the preceding section devoted to the Willow Creek Basin.

139. Laminated dark red sandstone, underlaid by red shales. This ledge shows in an obscure outcrop in the shallow saddle on the crest of the ridge immediately east of the extreme source of Tin-Cup Creek, which at the point where we crossed attains an elevation of 1,700 to 1,800 feet above John Gray's Lake, or nearly as much lower than the summit of Mount Caribou, a couple of miles to the northwestward.

140. Space several hundred yards across, showing obscure exposures of red shales.

141. Brownish gray sandstone, obscure exposure.

142. Unexposed space.

143. Drab, spar-seamed, fragmentary limestone, dipping about 35° southwestward. This forms a heavy ledge or deposit, plating the northeast steep border-slopes on Tin-Cup Creek, and which is traced as far as we could see in the direction of the strike, southeastward, where it seems to be cut through at the abrupt easterly bend of the stream in crossing this ridge. It is not very dissimilar to the limestone occurring in the summit at Station XXVIII, but the absence here of the heavy deposit of drab shales, which at the above locality underlies the limestone, militates against the supposition of the identity of these limestones.

144. Red shales, appearing in the valley of Tin-Cup Creek, a short distance above some abandoned reservoirs for the placer mines lower down this creek.

145. Gray and brown conglomerate and sandstone.

146. Red shales.

147. Gray, brown-weathered sandstone, heavy ledge.

148. Red and chocolate-colored shales.

149. Gray, thin-bedded sandstone.

150. Red shales.

151. Drab, fragmentary limestone, imperfect exposure of an apparently heavy ledge.

152. Chocolate-colored and red shales, with obscure exposures of brown-weathered gray sandstone.

153. Heavy-bedded, brown-weathered sandstone, in crest of rounded divide.

154. Space 200 to 300 yards, no exposure.

155. Gray sandstone ledge.

156. Unexposed space, 200 to 300 yards.

157. Heavy-bedded, gray sandstone and chocolate-colored shales, obscure exposure.

158. Red shales, including chocolate-colored, thin-bedded sandstone, imperfectly seen in the shallow valley of a tributary of Tin-Cup Creek.

159. Heavy-bedded gray sandstone.

160. Unexposed, space 100 yards.

161. Gray, reddish weathered sandstone, in crest of low water-shed, between Salt River and Gray's Lake drainages.

162. Unexposed.

163. Buff gray sandstone, and brown earth or shales, obscure exposure.

164. Unexposed.
165. Obscure exposure of gray sandstone.
166. Red shales, exposed in the northeast slopes of narrow valley tributary to Gray's Lake.
167. Heavy ledge gray, brown-weathered, laminated sandstone; dip 35° to 45°, southwestward. Forms a conspicuous escarpment in crest of low ridge through which the little stream breaks its way out to the long, gentle slope descending to the level of John Gray's Lake plain.
168. Gray, brown-weathered, spar-seamed sandstone, forming four or five ledges, and interbedded with chocolate-colored and pale reddish shales, which appear in the open, grassy slopes over a belt several hundred yards across.
169. Flat alluvial valley, traversed by a small stream that flows out into the flats of John Gray's Lake, two or three miles to the northwest.
170. Gray, thin-bedded sandstone; dip 30° S., 60° W. Exposed in gentle slopes on the southwest side of the valley, and rising into the undulating upland south of John Gray's Lake, in which the following obscurely exposed strata appear.
171. Unexposed.
172. Gray, thin-bedded sandstone, dip southwestward.
173. The above ledges are followed by several successively higher and similar soft sandstone beds, which show obscure outcrops in the undulating upland which occupies a breadth of about three miles, the inclination of the strata gradually flattening to the southwestward, where they sink into a shallow depression and disappear.

Just beyond the point mentioned under 173 of the above section, a low and more abrupt ridge intervenes between this depression and a southeast tributary of John Gray's Lake, in which obscure exposures of red and light shales were observed (174), and on the summit, at an elevation of 300 to 400 feet above the plain, dark gray sandstone and gray and buff limestone *débris* occur (175), the latter abounding in *Ceratites.* The latter deposits were not seen *in situ*, and their relation to the foregoing soft sandstones and pale red shales, which compose the whole of the upland tract to the northeast and reach up on the southwest flank of the Caribou Range, was not ascertained. The latter locality is just over our south line. In the country to the southeast, Dr. Peale discovered the same ledge in place, from which he brought in a suite of its peculiar fossils, amongst which Dr. White has recognized several species of *Ceratites.* This ridge is separated from the low hills outlying the Gray's Lake ridge on the northeast, by a rather wide, estuary-like arm of Gray's Lake Basin, which soon narrows and is choked with the basaltic flows that form the lower divide between this and the drainage flowing south. These low, outlying hills are composed of dimly exposed red-colored deposits, resembling the softer shales in the above-mentioned ridge, and which dip apparently southwest. The interval between these ridges is, however, filled with the basaltic flow, completely interrupting the continuity of the sedimentary exposures. To the southward or southeastward these deposits have the appearance of dipping into the low mountain ridge on the southwest side of John Gray's Lake, and which at the southernmost point visited, a mile or two south of the lake, was found to exhibit an interesting anticlinal fold, with the appearance of the strata curving round the southeast extremity of the ridge, where, as elsewhere observed, are massed heavy deposits of red beds. But within our territory that portion of the ridge south of the wagon-road gap presents the structure of a monoclinal ridge composed of Carboniferous deposits. I am strongly inclined to the belief that a belt or zone

along the northeast border of this ridge occurs in which the strata have been greatly disturbed, probably resulting in faulting or sharp folding, by which the beds on the northeast side were suddenly dropped down or greatly pinched. More than this was not suggested by the appearances as seen from a distance.

With a brief review of the leading stratigraphic and structural features elicited in the course of the examinations detailed in the foregoing sections closes the account of the observations made in this most interesting mountain range. The eastern portion of the McCoy Creek section shows a rather broad and shallow synclinal depression (A), the outskirts of which are based upon a series of red sandstones and variegated red and drab shales, which are doubtfully regarded as of Triassic age. This depression is the same as that previously observed to the west of Station XXVI and east of Station XXVII, and which apparently runs out to the southeast into Salt River Valley. To the northwest, beyond the above-mentioned point west of Station XXVI, it is possible that this fold corresponds to the synclinal trough lying between Stations XXI and XXIV, beyond which it seems to curve round more to the west, where it may pass out into the western border of the northern portion of the range, but where it is buried beneath the volcanic flows. The identity of the above-mentioned synclinal depressions is, however, rather suggested than demonstrated; but when we take into consideration the average prevalent direction of the strike of the strata, it seems so well borne out as hardly to admit of a doubt but that they belong to one and the same trough.

Some three and a half miles within the debouchure of McCoy Creek the strata rise up in a rather narrow fold (B), with steep or vertical dip on the southwest flank, where the dark-weathered conglomeritic sandstones are seen to arch up toward the crest of the fold in the escarpment exposures on the south side of the stream at its north bend. This fold is unmistakably identical with that in Station XXVII ridge, the axis of which also corresponds to the crest of the lofty massive mountain a few miles to the northwest, whose summit dominates the region between McCoy and Pyramid Creeks. Beyond the latter point, however, it is not so clearly traceable. There are uplifts and westerly inversions in the vicinity of Stations XXI and XX, which certainly occur in line with the prevailing strike of the strata between these distant localities, but at the latter locality they are so different physically, and more complicated, as to conceal their relations until the structural features were plotted on the topographical sheets; for on McCoy Creek it does not appear that the uplift was so great and the lateral forces so powerful as to topple the fold over, inverting the strata, such as doubless was the result in the northwest. Yet we find an approach to such a state of things, the western flank showing beds tilted to verticality, though they soon resume gentler inclination, and finally sink into a moderately-shallow synclinal trough (C). Southwest of the axis of the latter depression the strata gradually steepen in their rise as we pass up the valley until reaching a point 1½ to 2 miles by the stream, but probably within that distance along a line at right angles to the strike, when they abruptly flatten out in a broad-topped arch, a couple of miles across, as shown at D. The present uplift must represent a displacement of at least several hundred feet, bringing to view a calcareous horizon, which probably belongs to the Jurassic. The synclinal on the northeast is mainly filled with sandstones and shales, in regard to the age of which more explicit data was not obtained than that they are of later date than the Jurassic limestones, which form the central bands in the anti-

clinal B, with which they are apparently conformable. The same series of deposits, indeed, recur in the northeast border slopes of the Fall Creek mountain-basin, where, however, they appear in an inverted position, and merge into the plant-bearing gray sandstones of the Laramie (?) Group. The southwestern flank of this flat-topped uplift is not well seen, but it appears to decline gradually into a narrow belt of greater disturbance, where its component strata again begin to rise. Perhaps half a mile below the upper basin these strata are suddenly uplifted and toppled over past the vertical on the northeast side, sweeping over in an undulating, gently-inclined arch, and pitching steeply on the southwest flank, the fold, as seen in the north side of the valley, presenting the appearance indicated in the diagram at E. The exposed strata in the above uplift are apparently identical, lithologically, with the upper horizons in the broad-topped fold D. One or both of these folds reappear in the broad ridge between Station XXVII ridge and Mount Caribou, the comparatively gentle summit slopes of which may have been determined by the moderately-arched strata which form the roofs of these arches. The latter feature was distinctly displayed from both of the above-mentioned points of observation, which, but for the forests, commanded unobstructed view over this elevated mountain tract.

Once within the upper basin of McCoy Creek the lithological characteristics change, a heavy series of, however, comformable deposits, consisting of gray, shaly, spar-seamed sandstones and variegated shales, thrown into sharp folds (F and G), succeeding and approaching Mount Bainbridge, preserving uniform southwesterly inclination, as has already been noticed.

Overlooking the low hills along the north side of the main western branch of McCoy Creek, and which extend over the low water-shed into John Gray's Lake basin, a fair exhibition of the sedimentary rocks there occurring is presented from the summit of Mount Caribou. This region embraces a radius of about one-eighth of a circle, and continues the section from about the southwest dipping horizons between that mountain and the anticlinal (G) next east. The section, as seen from this distance, is conspicuous for the predominance of red-colored strata; but its chief interest is derived from the rather complicated structural features which the exposures reveal, and which are worthy of attention. Descending into John Gray's Lake basin from the low ridge southeast of Station XXVIII, the dip of the strata was uniformly to the southwestward, gradually flattening out as we progressed in that direction; but in the above-mentioned quarter it is apparent a far less simple state of things exists. Outlying, or rather continuing the southwesterly inclination of the gray sandstones and wider belts of pale red softer deposits which recline on the southwest flank of the anticlinal fold G, the strata are observed gradually steepening the angle of their inclination, until, at a point about northwest of Station XXVIII, a belt of these red beds shows the strata tilted into positions wavering to one or other side past the vertical, followed by a broad belt of similar colored strata dipping to the norteastward. This has the appearance of a pinched synclinal, but a closer examination might resolve it into a more regular trough-like fold. Immediately to the southwest a heavy deposit, consisting of red and light-drab strata, rises up into the crest of the watershed, where they form a rather sharp arch, succeeded by a heavy series of red beds, which latter dip more and more moderately as they near the borders of John Gray's Lake plain, precisely as has already been seen in the slopes south of Station XXVIII. In both the lithology and magnitude of the folds there is a striking and most intimate resemblance to the section

previously described on the east fork of John Gray's Creek, a few miles to the northwest, while the trend of the folds at the latter locality renders it almost certain that the two sections are structurally, and probably stratigraphically, identical. Could it have been determined by actual examinations whether the trend of these prominent structural lines in the present quarter bear a little east of their apparent regular course, which they are known to do within still more local limits, the above anticlinal and synclinal folds might have proved to be actually identical with the folds G and F of the McCoy Creek section. This interpretation would at once refer the exceedingly variable and complicated structural features noticed in the vicinity of Stations XVIII and XIX to the remarkable exhibitions of vertical displacement which are so unmistakably displayed at the upper entrance to McCoy Creek Valley, and which are shown at E in the accompanying diagram of the McCoy Creek section.

In connection with the sedimentaries in Mount Caribou are associated volcanic phenomena of greatest interest. Scarcely is the ascent of the northeast spur along Bilk and Iowa gulches begun, when intrusive ledges of volcanic matter appear; but it is only on gaining the crest and examining the section exposed in the walls of the little amphitheatre just under Station XXVIII that their true relations were unequivocally disclosed. It would, however, require a much more extended examination than any we were able to make in order to describe in detail the variable character of the eruptive materials here met with, and which is barely more than hinted in the description of the foregoing section. Besides the regular intruded sheets of volcanic matter, the shales in certain horizons seem to have been permeated with mineral vapors, to which may be attributed the formation of the "mineral pockets" met with in these deposits. The whole mass of the sedimentaries has undergone metamorphism to greater or less extent, either by direct contact with the intruded sheets or by less direct though probably equally potent influences arising from the same source of volcanic action. But, besides the intrusive matter, there occur exhibitions of eruptive origin on even a grander scale. A short distance from the summit in the northeast face of the mountain there appears a nearly vertical dike-like mass of dark bluish-gray eruptive rock, which has a strike approximately east-west. Passing out along the crest of the western spur of the mountain, the sloping summit is paved with limestone and brittle metamorphosed slate, the latter terminating in a nipple half a mile or so west of the station, where it is associated with a gray sandstone. At the latter point the sedimentaries are cut by an enormous mass of eruptive character, consisting of a dark bluish-gray, hornblendic trachyte, like that in the before-mentioned dike under the northeast brow of the mountain, and which presents more the appearance of an extremely fine, syenitic rock, in places changing to a schistose character from the prevalence of mica, which but for the fact of its unmistakable origin would be unhesitatingly referred to the metamorphic schistose series. This mass is succeeded on the west by a pinkish-gray, hornblendic trachyte of similar character, occurring in weathered slabs, and which extends far down along the crest of the steeply descending spur, until its foot merges into the low, rolling sedimentary hills which here flank the mountain, and in whose bared sides exposures of red shales and sandstones reappear, inclining to the southwest. This spur forms the southern rim of the great crater-like excavation in the northwest face of the mountain, the distant view of which presents so interesting a feature as seen from that direction. The northern spur appears to be made up of sedimentary and

intrusive ledges similar in position and mode of occurrence to the exposures in the before-mentioned amphitheatre walls. About a mile southeast of Station XXVIII, the mountain rises into a second prominent summit. Passing the saddle between these points, the whole southwest face of the mountain is covered with the angular slabs and *débris* of dark-bluish to greenish-gray, hornblendic trachyte, weathering to a pale-reddish hue. In the latter mountain-peak the eruptive mass seems to rest upon metamorphosed bluish slates, the line of junction pursuing a northwest and southeast course, the slates dipping southwestwardly. The eruptive material here has more the appearance of a wedge-shaped mass, though it was undoubtedly connected with the dike-like effusion in the west spur of the main summit; and so, also, with the intrusive sheets which were noticed in the northeast face of the mountain. Hence, it appears that the phenomena observed at this locality suggest one of those local outbursts or a concentration of volcanic activity, by which the sedimentary deposits were fractured and split apart, the molten matter in the one case forming wedge-shaped dikes, and in the other intrusive sheets following the plane of bedding. It may be that this locality marks a centre of eruption from which were derived much of the earlier volcanic products which were spread over the mountain summits, remnants of which are still to be found on high eminences. But the imperfect study we were able to make rather leads to the conclusion that at the time of this eruption, which was doubtless subsequent to the disturbances by which the sedimentaries were upraised and folded, the volcanic activity was wholly subterranean in its manifestation, and that the present appearances at the surface are due to the excessive denudation which the region has been subjected to within a comparatively modern date.

This locality is one also of unusual economic interest and importance, on account of its placer mines. These are situate along Iowa Gulch, a main tributary of McCoy Creek, and on the upper course of Tin-Cup Creek, which flows south and east into Salt River, a few miles above its confluence with the Snake. At the former locality the mines are operated by the usual various processes, and at the time of our visit there were about twenty-five whites and three or four times as many Chinamen engaged in the works. The mines were discovered in 1870, since when the district has had a fluctuating population, and though, perhaps, never remarkable for extraordinary yields in gold, the present occupants of the mines claim to be reaping fair returns. The auriferous gravels are principally accumulated in what is known as Bilk's Gulch, which rises immediately under the summit of Mount Caribou, and consists of abraded volcanic and sedimentary materials largely mixed with the red earth derived from the softer shales. The mines are distributed along Bilk's Gulch and Iowa Gulch to its confluence with McCoy Creek, a distance of about three miles. The chief difficulty, as usual, is the limited supply of water, which is said to last about three months, the "cleaning up" requiring a month or so more, for which a limited quantity of water suffices. As to the productiveness in gold of these placers, nothing definite was ascertained. The placers on Tin-Cup Creek are also said to be moderately productive; but the single day we had at our disposal for the examination of this section did not permit visiting this locality. Gold has been obtained in the sands all the way down the valley of McCoy Creek, and, I believe, in the bars along the Snake, but not in remunerative quantity. Indeed, the whole region has been pretty thoroughly ransacked, and prospect excavations were encountered in the most extraordinary and unexpected places.

From what has been said, it is evident that the source whence the

placers derived their gold is situated in Mount Caribou. At the time of our visit I was fortunate to meet one of the partners of an enterprise looking to the development of the parent lodes. Messrs. Griffin & Noelans have begun a shaft upon a lode which outcrops high up on the southerly declivity of the peak a mile to the southeast of Station XXVIII. The lode has a strike about N. N.W. and S. S.E., nearly vertical, or inclined southerly, if at all, and seems to be very wide; indeed, no well-defined walls have as yet been discovered, the exploration having been carried to a depth of about 60 feet by an excavation 8 feet in diameter. It is composed of rotten ferruginous quartz inclosed in the peculiar tough trachytic mass, its relations apparently being that of a dike or true vein, which may also traverse alike the sedimentaries and eruptive materials. No assay of the lode-rock had been made from which even an approximate knowledge of its value might be gained; but a little gold has been extracted by the rather crude processes at command of the explorers. I believe there are other "discoveries" of similar character in the neighborhood, but none developed to the same extent as that above noticed. In the vicinity of the Griffin lode, some 300 yards to the southwest, a vein of magnetic iron ore has been discovered in the hornblendic trachyte mass which forms the bulk of the western side of the mountain. This vein, from which specimens were obtained, is said to be 20 feet wide, and extends in a northwest and southeast direction, or nearly parallel with the above-mentioned auriferous lode.

LOWER VALLEY OF SNAKE RIVER.

That portion of the course of Snake River below the grand cañon traverses a typical valley trough defined on either hand by mountain barriers, to which we have applied the term lower valley of the Snake. This valley, with its southern continuation in Salt River Valley, has a northerly and northwest course of about fifty miles within the district, and an average width between the crests of the opposing mountain ridges of eight to ten miles. To the northwest it opens out into a wide recess communicating with the Snake plains, the barrier ridge of the Snake River Mountains throwing out a long low spur along the northwest border considerably beyond the terminus of the Caribou Range on the southwest side of the valley. The often-mentioned volcanic upland bordering the Snake plains sweeps round the extremities of the above ranges, filling the broad debouchure and extending up the valley half the distance to the grand cañon, forming a continuous sheet of volcanic materials with that which fills the Willow Creek Basin to the south and similar recesses to the north.

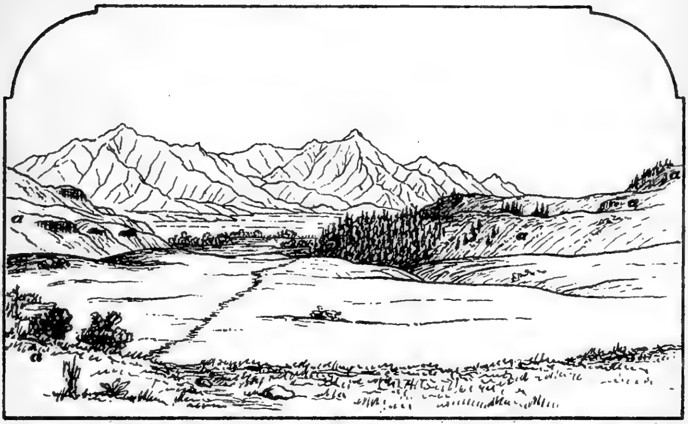
A few miles below Fall Creek, at the point where the river makes a bend to the north, it begins its cañoned course in the basaltic rocks, which thence confine the river in a narrow channel between precipitous walls of dark lava, until it emerges into the level plain, 15 to 20 miles below. Above this lower cañon pretty little alluvial expansions border the stream, at intervals interrupted by high, jutting benches of the volcanic rocks, until just above Fall Creek the stream opens into a considerable basin area, floored with Quaternary gravels which are fashioned into low terraces. This prairie bottom extends a distance of 6 to 8 miles up the valley, mainly lying along the opposite side, the stream skirting the foot of the volcanic bench on the southwest side, with here and there narrow intervale tracts intervening. Approaching Pyramid Creek the volcanics again converge from either side, forming the narrows through which the stream winds amidst varied, picturesque scenery a distance

of 4 or 5 miles, when it expands into the beautiful and still more extensive upper basin which extends to the mouth of Salt River, above which it expands into the basin-like area through which that stream flows from the south. Above the narrows the volcanics suddenly cease, and thence southward the bared sedimentary formations appear in the abrupt slopes of the border mountains between which the terraced bottoms stretch from side to side.

Our route entered the valley just above the north bend, where the stream enters the lower cañon in the basalt, and thence followed up along the southwest side to the confluence of Salt River. The character of of the volcanic materials at this point was casually mentioned in connection with the description of the section through Station XXIV, in a preceding page. They are seen to be made up of pinkish and drab trachytic flows, associated with peculiar light, soft materials, recalling modern Pliocene deposits along the border of the Snake plains, and reclining directly upon the sedimentary deposits which compose the border mountain flanks. These flows dip gently northward in the direction of the lower level of the volcanic plain which fills the debouchure of the valley, and which has the dark, somber appearance of basalt. Just above the little recess at Butte Creek, which is shut off by a low butte capped by trachyte, we regain a larger bottom tract which reaches a mile or two along the stream on the south side, extending back to the foot of the mountain, which is here denuded of the volcanics; the north side of the stream still showing a high bluff of volcanic rock, underlaid by lighter colored deposits. This bottom is made up of gravel, which forms a bar-like dry ridge between the stream and a low, marshy tract inland, and is further molded into low terraces. The turbid, swift-flowing river is filled with low islands, covered with willow and cottonwood, and dense copses of wild rose. The volcanic bench again approaches the stream, along which it forms bluffs a hundred feet or more in height, gradually rising up on the neighboring mountain flank. Fall Creek, after leaving its debouchure in the mountain border, cuts a narrow cañon across this bench, and on reaching the left bank of the Snake its waters are precipitated over a ledge of basalt, making a pretty fall of 30 to 50 feet in height. The section of the volcanics exposed in the cañon wall of Fall Creek is one of much interest, inasmuch as it exhibits the relative position of the trachyte to the overlying basalt, both of which incline off the sedimentary border ridge. At this locality the trachyte was seen at an elevation of 700 to 800 feet above the river, in close proximity to exposures of Carboniferous limestone, the basalt not reaching the same elevation, its limit being rather well defined by a bench-like break in the sloping surface. The basalt is the usual dark gray or brown vesicular variety, holding small globules of white quartz which have a fused appearance. It occurs in heavy layers, broken into irregular cross-fractured columnar fragments, and undulating as though the material flowed over an uneven surface. The same ledges appear in the bluff-face of the lower plateau bench that fills the opposite side of the valley, where, however, they appear to incline gently in the direction of the opposed mountain border. This appearance is not readily accounted for, unless the flows have been slightly tilted by forces acting in the mountain belt along the southwest border of the valley.

This high volcanic bench continues thence to Pyramid Creek, everywhere showing the same sloping surface outlying the sedimentary mountain border, across which numerous little streams have eroded deep, narrow channels, on their way to the river. On the opposite side of the valley, corresponding benches are seen along the farther border of the

PLATE XXIX.



Snake River Mts. Lower Basin. a. Volcanic benches.

Lower Valley of the Snake above Fall Cr.
Looking E.S.E.

Lower Valley of the Snake above Fall Creek. (Looking North).

a. Trachyte. b. Conglomerate. c. Volcanic benches. d. Carb. (?) Snake River Mts.

large basin tract which here occupies the valley. Along one of these little cañonst, hree miles above Fall Creek, interesting exposures of the volcanics were met with, a section of which is reproduced in connection with the section-diagram of the mountain border north of Station XXV, where their relations to the sedimentaries, as also the relative position and succession of the somewhat variable elements of which they are composed, are well shown. The section here referred to exhibits the various sheets of volcanic material rather rapidly rising from the river bluffs inland, where they reach an elevation of 800 to 1,000 feet above the river-level. The inferior flows appear well up the cañon in the neighborhood of the sedimentary flank of the mountain, whose foot they bury from view; but the northerly inclination is apparently sufficiently steep to carry these deposits beneath the river-level, the descent being somewhere between 500 and 600 feet in a distance of perhaps one and a half miles. The lowest member, *a*, shows an exposed thickness of about 30 feet of dark drab trachyte. This is overlaid by *b*, dark, vesicular, rudely bedded basaltic lava, 25 feet or more; *c*, pink trachyte, or tuff, rather hard and weathered in slab-like fragments with a bedded appearance, 30 feet or more; *d*, conglomeritic deposit, made up of water-worn pebbles of quartzite, limestone, &c., without distinct arrangement in layers, held in a buff-drab matrix like a volcanic paste. This deposit attains a thickness of 100 feet or more, forming picturesque mural bluffs on the water side below the mouth of the gulch, and rising inland, southward, its *débris* scattered thickly over the surface of its outcrop like accumulations of glacial drift. In the river bluffs and inland it is overlaid by *e*, a volcanic ledge consisting of maroon-drab trachyte, laminated gray trachyte or trachorheites, and intensely hard, dark, basaltic lavas, showing an exposed thickness of about 25 feet. The latter flow extends high up on the foot of the mountain, occurring in sloping plateau-like benches. The variety in the character of the components of the volcanic deposits at this locality may not indicate so many distinct epochs of eruption and flow, the different materials apparently having followed without cessation, in alternating order. Yet the presence of the interpolated conglomerate evidently shows an interval between the earlier and later trachytic flows sufficient for the accumulation of a heavy deposit of erratic materials which subsequent volcanic action, by affecting its partial transformation, partly claims for its own. This deposit, physically, bears intimate resemblance to that which crowns the summit of Station XXIII in the northern part of the Caribou Range, and which seems to form the basis of the volcanic rocks at that place; the chief differences noticeable being its inferior position and the more distinct conglomeritic instead of brecciated character, from which it may well be inferred the two deposits are not contemporaneous, although, perhaps, similar in origin.

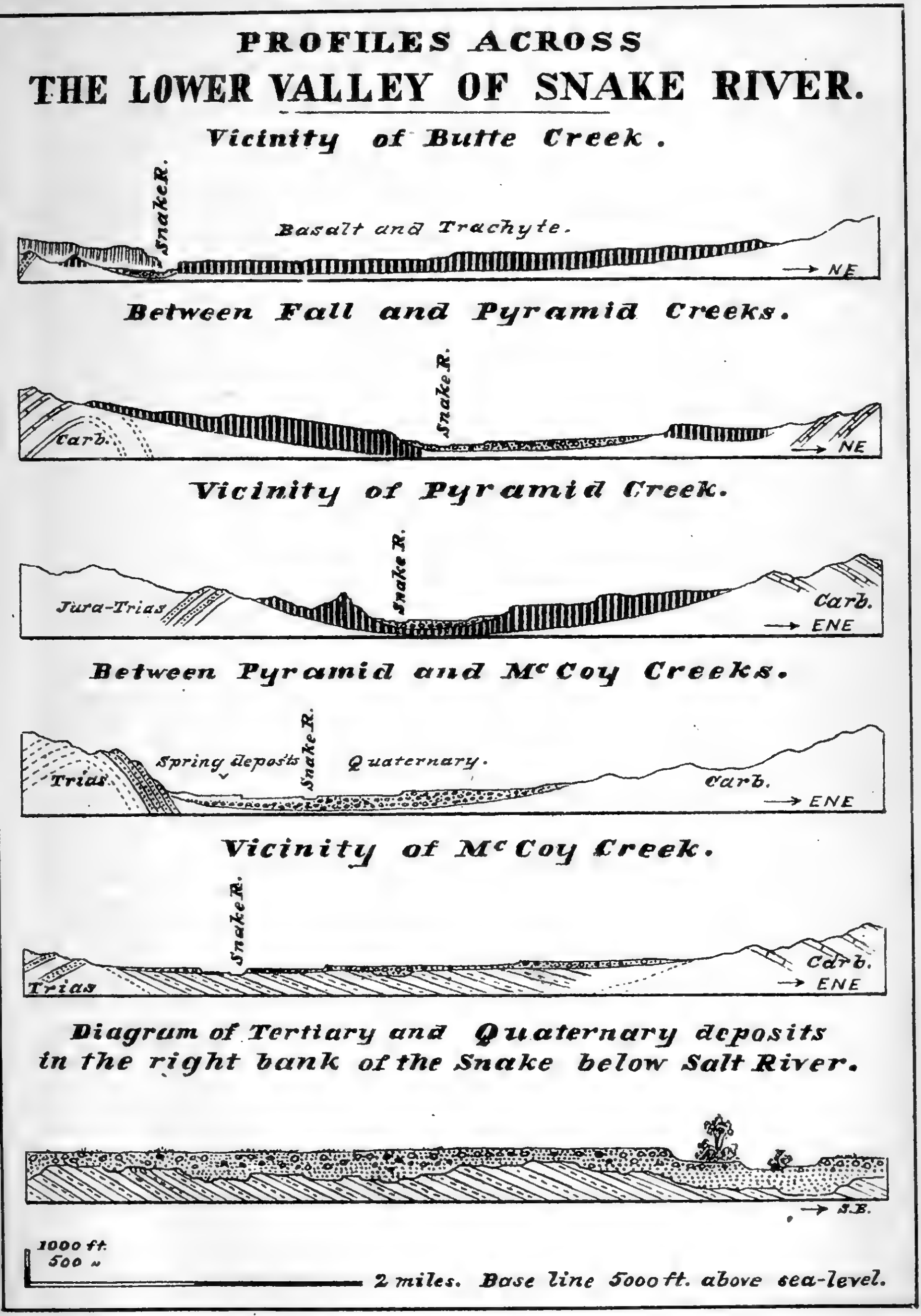
Many beautiful views are gained from the trail passing over the high benches, stretches of wide bottom plain, through which the gleaming river winds in majestic curves, its surface studded with beautiful islands and the banks lined with tall cottonwoods, here bordered by mural bluffs of volcanic rock, fringed with dark-foliaged pine and fir, and the whole bounded by rugged mountain walls, which stretch away in long lines of perspective until lost in the distant windings of the valley. Certainly, few localities afford the same varied and none more beautiful scenery than frequently greets the traveler in the lower valley of the Snake. One of the prominent heights on the opposite side of the valley, about midway between Fall Creek and Pyramid Creek, to which Mr. Bechler gave the name Promontory Peak, presents a singular phenomenon in

the distribution of the scant forest-growth over its rugged valley aspect. The arborescent vegetation extends two-thirds the way from the base toward the summit, where it is terminated by a sharply-drawn horizontal line, extending quite around the visible face of the mountain, above which the bare, rocky crown rises into the massive cone of the summit. The mountain attains an actual altitude of 9,900 feet, or 4,500 feet above the valley, so that the limit of the forest growth is considerably below the general altitude of timber-line in the neighboring mountains. But it may, with some reason, be attributed to meteorological influences, and to which the universally sparse-clad southwest slopes throughout the lower mountain-ranges bordering the Snake plains are alike attributable. The prevalent winds during the term of our sojourn were from the southwest, hundreds of observations, such as the bent boughs and unsymmetrical tops of the trees exposed to their force, everywhere attesting the violence of the winds, while the opposite slopes and deeper ravines, which are sheltered from the fierce blast, are quite generally clothed with valuable forests. Almost the same observations hold equally true in the distribution or maintenance of the drifts of snow, the drifts on the southwest-facing slopes being licked up or evaporated by the searching winds before the season is far advanced, while *couloirs* and snow-cornices may remain the whole summer just over the crests. It is a singular fact, though not a universal one, that the majority of the amphitheatres and abrupter breaks in the mountainous districts face the east or north, as though the frost-bound side had the major share in the slow process of mountain sculpturing. In this way, very many of the loftier peaks bordering the Snake Valley present amphitheatre excavations in their northeast faces, while that toward the valley rarely shows so extensively eroded depressions, however rugged their aspect may be, and, indeed, usually is.

Above the latter locality low bluffs of dark basaltic rock approach the southwest margin of the river, along which narrow tracts of alluvial bottom land border this side of the stream, which on the opposite side expand into the gravelly sage-covered plain of the lower basin. Higher up the valley the sedimentary mountains on either side approach nearer, the volcanic benches becoming higher and crowded into a narrow space, where they form a line of quite prominent bluffs on the northeast side, the bottoms being crowded to the opposite side, where they were found to be composed of coarse, water-worn materials, built up into low, well-defined terraces 10 to 25 feet above the present level of the stream. At the upper end of this bottom tract, a prominent pyramidal hill chokes the valley; it was found to be composed of flesh-colored trachyte with darker volcanic ledges, and which doubtless is a remnant of the volcanics which formerly flooded the entire valley. Above this conspicuous landmark, to which the name Pyramid Butte was given, the volcanics cease on the southwest side of the valley, which opens out in a fine terraced tract filling the debouchure of Pyramid Creek. There are at least four distinct terrace levels, of which the two upper and more prominent reach a height respectively 40 and 90 feet above the level of the river. On the opposite side the volcanic bench terminates in high bluffs, and at the narrows, a short distance above, it breaks down vertically, in picturesque palisades several hundred feet in height, whose base is swept by the powerful current of the river.

A marked change at once takes place on entering the upper basin of the valley. If ever the volcanics extended farther than the narrows, they have been entirely swept out of the upper basin, which is occupied by a fine wide bottom tract based upon a deposit of water-worn pebbles

PLATE XXX.


PROFILES ACROSS
THE LOWER VALLEY OF SNAKE RIVER.
Vicinity of Butte Creek.
Snake R.
Basalt and Trachyte.
NE.
Between Fall and Pyramid Creeks.
Snake R.
Carb.
NE
Vicinity of Pyramid Creek.
Snake R.
Jura-Trias.
Carb.
ENE
Between Pyramid and Mc Coy Creeks.
Snake R.
Spring deposits
Quaternary.
Trias.
Carb.
ENE
Vicinity of Mc Coy Creek.
Snake R.
Trias
Carb.
ENE
Diagram of Tertiary and Quaternary deposits
in the right bank of the Snake below Salt River.
S.E.
1000 ft.
500 "
2 miles. Base line 5000 ft. above sea-level.

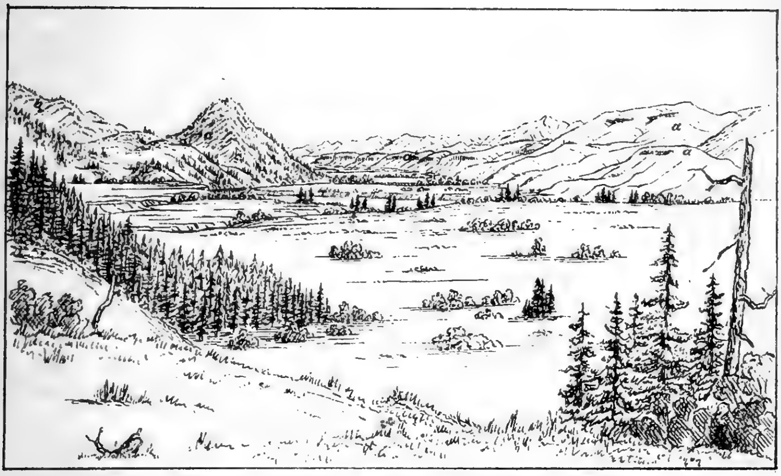
and alluvial matter, arranged in a series of much more prominent terraces than any occurring in the lower basin, the highest of which do not exceed perhaps 50 feet, while the lowest is only a few feet above the river level; the valley is narrower, but the alluvial terraces occupy the whole space intervening between the foot of the abrupt mountain borders. Numerous small streams debouching from the hills have swept down quantities of *débris*, which is piled in low-spreading accumulations like the tailings of a sluice-way; their waters are often spread over the more level bottoms, where they to-day form extensive areas of miry soil, but which will one day be converted into invaluable meadow tracts. At several places along this side of the valley, between the narrows and McCoy Creek, extensive deposits of calcareous tufa occur in two or more flat terrace levels, which at one point reach the present margin of the stream. The highest of these regular-shaped terraces is about 15 feet above the adjacent bottoms, and is terminated abruptly in a miniature escarpment which was once washed by the stream. At one place just above this tufa terrace, low, dome-like deposits of white tufa were seen at the foot of the mountain, evidently the accumulation of a still flowing spring. The pools here and there found on the lower tufa flats, which here form an extensive deposit reaching the river side and some 6 feet above the water-level, were tepid and very perceptibly saline; their beds are covered with an ochreous-colored precipitate, and the unctuous soil saturated with the mineral substances from the springs was devoured with avidity by our animals. Professor Bradley describes a group of warm springs occurring on the opposite side of the valley, which have built up similar "calcareous, sulphurous, and saline deposits," their temperature ranging from 88° to 144° F. The west side springs are, however, in an advanced stage of extinction compared with their former flow, when they built up the extensive, ancient-looking terraces. But the very modern date of even the more ancient of these spring deposits may be inferred from the total absence of river drift upon their surfaces. In crossing these old spring deposits, our animals' tread gave out a hollow, resonant sound, which may be due to the imperfectly impacted layers which are separated by minute cavernous or porous spaces.

We now come upon an interesting series of deposits, which, though of much more ancient origin than any hitherto mentioned, are apparently equally restricted in their distribution within the limits of the valley. These were first encountered ascending the valley a few miles below the mouth of Salt River—the exposures only appearing in the higher river banks and terraces cut by the inflowing tributaries, and extending south as far as our examinations were carried, and beyond, on the one hand, quite to the debouchure of the grand cañon, and on the other, up the valley of Salt River. They consist of drab and light-brown sandy clays and partially indurated buff and brownish sands, banded with various shades of red in thin layers, giving to the exposures a very beautiful variegated appearance. As before mentioned, these deposits outcrop quite extensively in the higher terrace banks along the river, where they may be well studied. They dip eastward or northeastward with great uniformity, probably at angles of 25° to 40°, or inclining obliquely upstream. In the valley side, at the debouchure of McCoy Creek, they are seen resting unconformably upon the southwest-dipping Mesozoic sandstones, and also along the west side of Salt River, above its mouth. But the river-bank exposures afford the most interesting sections. Here the beds appear planed off to various levels by the former action of the stream, showing shallow channels with low-terraced margins, upon which subsequent depositions of water-worn bowlders, gravel, and sands

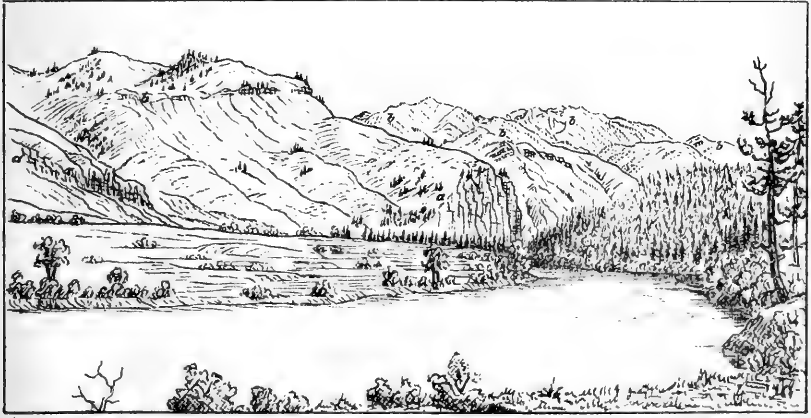
were spread over their upturned edges, and which latter deposits constitute the existing terraced surface of the valley. At one point the planed-off edges of the beds are curiously turned up, as though some heavy body had been forced over their tilted edges in the direction of their dip.

No paleontological evidence was observed by which the age of these latter deposits might be fixed. They differ in so marked degree from anything elsewhere observed in this southwestern section of the district, both in their lithology and position, as to leave little room for doubt as to their comparatively modern date. In both of these respects they offer marked resemblances to deposits occurring in the region of the headwaters of the Missouri, which Dr. Hayden has described under the term "Lake Beds," and which he provisionally referred to Pliocene Tertiary age. Yet they may be found to pertain to the great Wasatch Group of Tertiary formations so extensively developed in the region to the south. Their occurrence in the lower valley of the Snake offers further phenomena of interest in connection with their relation to the surrounding and more ancient mountain barriers which define the basin in which these sediments were accumulated in horizontal strata. But their present inclined position, by which their upturned edges have been exposed to manifestly extensive fluviatile denudation, seems to be traced to late dynamical agencies resident in either one or other of the bordering mountain areas. Whether the indications point to a late upward movement in the Caribou Range or a subsidence in the opposed Snake River Range, which in either case would tilt the deposits that fill the intermediate valley trough into a position like that actually presented in the present series of beds, is a question which remains for more extended investigation to decide. Also, in regard to the age of these deposits, more cannot, in the present state of our knowledge, be inferred than their probable Post-Eocene age. In the Yellowstone expedition of 1872, Dr. Peale describes a series of deposits under the term "Lake Beds" or Pliocene, which occupy a basin between the Bridger and Spring Cañon Ranges, Montana, closely analogous in their occurrence and relations to the older sedimentaries, as here observed. But, to say the least, it would be premature to attempt the positive identification of these widely separated deposits one with the other. The Snake Valley beds differ in one particular from those above referred to in Montana, viz, in their more varigated, brighter colors; but this may be merely a local character, or, as above suggested, they may belong to an older member of the Tertiary formations.

PLATE XXXI.



Pyramid Butte, Lower Valley of the Snake. (Looking N.)
a. Volcanic. *b. Jura-Trias.*



The Narrows, Lower Valley of the Snake. (Looking East.)
a. Volcanic palisades. *b. Carbonif. limestones, Snake River Mts.*

CHAPTER III.

THE TÉTON, OR MIDDLE SECTION.

GENERAL TOPOGRAPHICAL FEATURES, DRAINAGE, ETC.

The region referred to under the above designation assumes the outline of a right-angle triangle, the base of which rests on the northern boundary and the two sides defined by the great southern bend of Snake River, its apex extended south nearly severing the district, of which it includes almost a third of the explored area, or approximately 2,000 square miles. Of this area perhaps one-third may pertain to the great basin region lying to the northwest and to which properly belongs the bay-like recess of Pierre's Basin, which latter separates the mountainous portion into a clumsy V-shaped area, which forms the whole of the eastern and two-thirds of the western side of the triangle.

The local drainage of this section mainly flows out into the great plain to the northwestward through Pierre's River, whose numerous affluents collect the drainage of the larger area of the Téton Mountains, the two principal branches rising at either extremity of the range above 40 miles distant, the North Fork heading in the extreme northern portion, and the sources of the main stream originating at the opposite or southern end of the range, in the vicinity of Téton Pass. Moody Creek and two or three smaller tributaries rise in the northern highlands of the Snake River Range, the former gaining Henry's Fork, independently, midway between the delta of Pierre's River and the confluence of the Snake. The mountain border region sends down myriads of little streams, the largest of which have a course seldom exceeding 10 miles, and which drain directly into the Snake. While many regions may be as thoroughly drained, few are so well supplied with noble rivers, rapid creeks, and beautiful mountain brooks as this which we have at present under consideration.

THE TÉTON RANGE.

The plains, which constitute a third or more of the northwestern portion of this section, form part of the great basaltic-floored basin of Snake River, which stretches along the northern border and far up Pierre's Basin, its eastern margin resting on the western slope of the Téton Range. This range, which holds a nearly meridional course, extending from the northern boundary of the district a distance of about 40 miles south, and ranging from 10 to 15 miles in east-west extent, is remarkable for its regular form, simplicity of geological structure, and the grandeur of the concomitant topographic features. The longitudinal axis of the range is crowded to the east, rising into a chain of Archæan peaks which culminates midway between the extremities of the range in a cluster of lofty peaks dominated by Mount Hayden, which attains an actual altitude of 13,737 feet. The eastern front breaks suddenly down in steep inclines to the level of Jackson's Basin, pierced by profound gorges which throw this aspect of the range into a series of gigantic buttresses surmounted by precipitous and embattled parapets.

The western side of the range descends much more gradually, and

where it is flanked by the sedimentaries the central portion of the range is fashioned into series of extensive amphitheatres and Alpine basins, in which the streams gather from their sources in the snow-flats to force their way through the cañons which score the great foreland descending into Pierre's Basin. The basis or foundation of the range is Archæan, which constitutes the northern three-fourths of the main crest, expanding in the northern half, where these rocks occupy the whole width of the range between Jackson's Lake and the volcanic foreland south of the North Fork of Pierre's River.

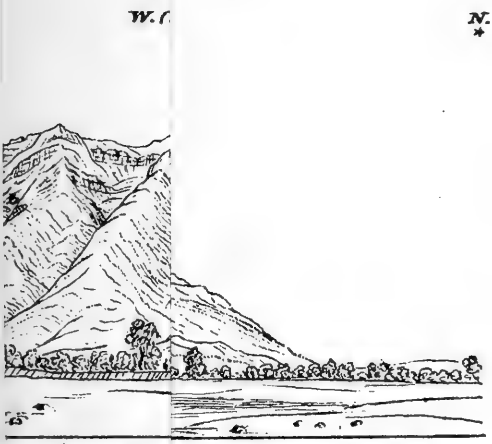
This Archæan expansion culminates in a lofty spur, which terminates in a pyramidal peak overlooking the densely wooded volcanic foreland, which here reaches high up on the mountain border, or a relative height of 2,500 feet above the plain north of Pierre's Basin. To the north the Archæan nucleus is prolonged in a narrow belt, which finally sinks beneath the upraised sedimentaries and volcanics which lap up around the northern extremity of the range, the latter merging into the great volcanic plateau which extends thence far to the north beyond our district. In the vicinity of the debouchure of Leigh's Creek the sedimentaries again peer out from beneath the volcanic flow, and thence southward they hold a prominent position in the western flank of the range, and toward its southern extremity completely bridge over the Archæan core, which descends in a rapidly narrowing belt in the eastern front, and finally disappears in the vicinity of East Pass Creek, beneath the level of Jackson's Basin.

As a whole, the topographic characteristics of the range may be likened to a great block tilted along its eastern border, the drainage of the western slope confined to long narrow cañons separated by broad intervening tables of sedimentary origin, while that of the east side lies in profound short gulches mainly excavated out of granitic or metamorphic rocks.

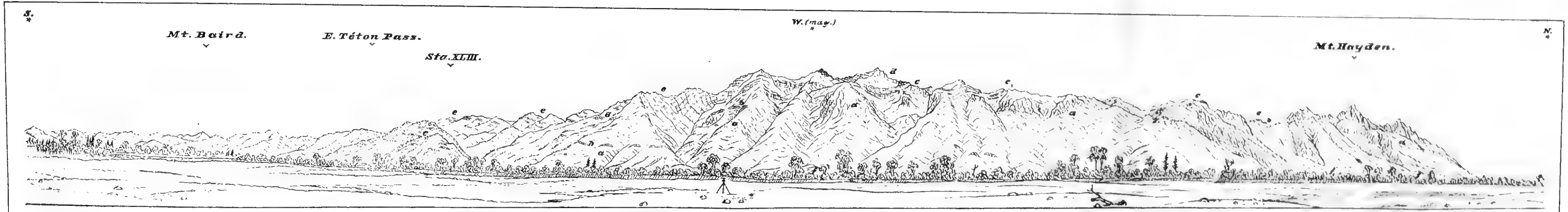
Although our own examinations afforded a pretty comprehensive view of the general geognostic features of the range, Professor Bradley had opportunity for prosecuting more detailed examinations in certain localities, which, for lack of time, we were prevented realizing to the same extent. In his report of 1872, he describes the Archæan area of the central mass to consist of micaceous, hornblendic, talcose, and chloritic granites, gneisses, and schists, the former white or flesh-colored, and occurring in massive beds. The gneisses and schists are much distorted, the prevailing strike holding an east-west direction, with variable and generally steep dips. These rocks are intersected by numerous large and small quartz veins, with a few of granite. On the North Fork of Pierre's River our young men succeeded in obtaining a single "color," indicating the auriferous character of some of these veins in that portion of the range at least. Besides these, there are a few dike-like exhibitions of dark trap-rock, which at some points Professor Bradley found conformable to the bedding of the granites, though it was difficult to decide whether their occurrence in this position should be taken as indicating their intrusive character, or were deposited as flows on the ancient surface upon which the inclosing sediments were accumulated. One of these trap-dikes forms a well-marked feature in the southern base of the great cone of Mount Hayden, which may be traced as a dark ribbon descending the west face and crossing intervening spur-ridges to the west, where it is lost beneath the quartzite of the Potsdam, which crowns the ridges in the neighborhood of the Pulpit.

A very similar dike, doubtless also trap, occurs in the northern half of Mount Moran, and which may be seen from either side, appearing like

Plate XXXII.



uth of larboniferous.
deposits.



a. Archæan. b. Quartzite. c. Quebec.

East Front of the Téton Range south of Mt. Hayden, from near Lower Gros Ventre Butte.

d. Niagara. e. Carboniferous. f. Morainal deposits.

a narrow ladder scaling the heights, the approximate direction east-west, with a slight southerly inclination from the vertical. In the northeast part of the range Professor Bradley remarked the occurrence, beneath the Silurian limestones, of "a heavy body of dark micaceous gneiss, with both granite and quartz veins," the metamorphics having a general southerly inclination, with, however, local northerly dips. Recognizing the identity of certain peculiarities of weathering with these determined gneiss exposures, which assume elaborate and beautifully carved surfaces, it appears that a large part of the east front of the range, as well as a wide belt, if not the whole of the northwest expansion of the Archæan area, is composed of similar rocks. The distinctively granitic ledges form the highest peaks of the range, as in Mount Hayden, peculiarly massive heights, with smooth, sheer precipices and huge block-like buttresses, while in the Alpine basins and cañon walls they appear in comparatively smooth surface-exposures, strongly contrasting with the generally sharp, highly-wrought sculpturing of the gneissic ridges.

In the course of our examination, in the northern portion of the range, a small area of Palæozoic formations was brought to light, which rise up on the northwest flank and cap the watershed for the distance of several miles, when they are headed off by the sag at the head of the south branch of the North Fork of Pierre's River, which also forms their southern limits. On the west they are soon hidden by the upraised volcanics, which latter sweep round the north end of the range and form a continuous belt with similar volcanic deposits, which rise up on the northeast flank of the range in the northern portion of Jackson's Basin.

Ascending from the plain north of Pierre's Basin to a prominent ridge at the head of the North Fork of Pierre's River, occupied by Station XXXII, the way for several miles passes over the laminated porphyritic trachytes which here constitute the great outlying foreland of the range, and which dip at a moderate and gradually diminishing angle of inclination in the direction of the plain. Along the mountain border they are suddenly terminated in irregular lines of bluffs, which on the main North Fork reach to within two and a half miles of Station XXXII, where their elevation is about 2,000 feet above the foot of the foreland. At this point the lowest of the sedimentaries shows a thin-bedded drab limestone, indistinguishable, lithologically, from the beds elsewhere found in connection with the Lower Silurian or Quebec formation. In the opposite side of a lateral gulch half a mile east, castellated exposures of heavy-bedded buff magnesian limestone, showing a thickness of above 100 feet, are met with, the rock affording a few Upper Silurian corals, *Halysites*, &c. These ledges form a prominent feature of the exposures in the steep slopes along the stream, and are succeeded by the ordinary gray and drab, cherty limestones, with interpolations of reddish siliceous deposits which make up a thickness of several hundred feet, and affording in their contained organic remains ample evidence of their Carboniferous age. The lower ledges are here arranged in courses interbedded with shaly layers, and underlaid by softer reddish deposits which intervene between the upper limestones and the underlying magnesian limestone. Above, the limestones become thicker, with siliceous interpolations, and often stained a pale red. Of these Carboniferous beds there is probably exposed in the ridge of Station XXXII a vertical thickness of 500 to 800 feet. In the summit these beds dip 20° northwest; in the northwest spur their inclination slackens, and toward the head of the before-mentioned lateral gulch the same ledges are seen to dip N. 50° E., at an angle of 25°. The facts above

alluded to are incorporated in the diagram of the section across the north end of the range given in an accompanying plate.

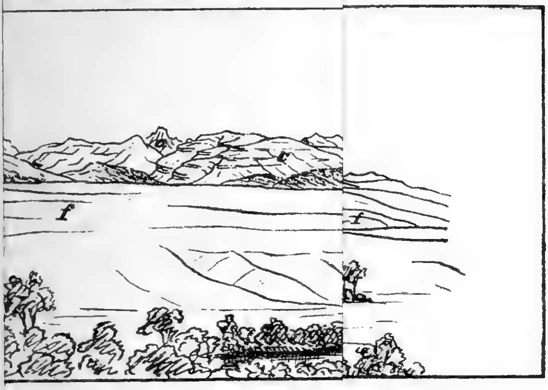
Station XXXII attains an altitude of 9,749 feet above the sea. The view from the summit, looking north and west, takes in the great volcanic watershed and the plain north of Pierre's Basin, the nearer slopes clothed in dense forests of pine and the higher mountain flats dotted with beautiful clumps of dwarfed spruces. To the east the view is shut out by higher ridges, in which appear long lines of strata probably referable to the Silurian, but here and there through the depressions appears the crest of the peculiarly weathered Archæan ridge, which is seen to pass northward much diminished in height and finally disappears. It was not certainly ascertained whether this latter ridge was denuded of its superincumbent sedimentary mantle prior to the flow of volcanic material or not, but such appears to be the case. But to the west the sedimentaries again intervene, as also to the east, in which latter quarter Professor Bradley found several hundred feet of limestone, representing the Lower Silurian to the Carboniferous, reclining on the Archæan nucleus of the range, and in turn overlaid by the volcanics. Hence there can be no question that at one time the sedimentaries folded around the northern extremity of the range, but subsequent denudation effected their removal down to a level which came within the reach of the great volcanic inundation, which at a comparatively modern date submerged so large an extent of the mountain border. Almost due north of Station XXXII, overlooking a small area of Carboniferous plateau in the foreground, beyond a deep gorge whose waters flow out into the Upper Snake Valley, the last elevation in this direction exhibits what appears to be a rather sudden upheaval of the strata, which in places apparently stand almost vertical, but with a general westerly inclination. Within less than a mile to the eastward the Archæan ridge passes behind a nearer ridge, and it seems highly probable that the flexure above mentioned is in some way intimately connected with the presence of this continuation of the metamorphic axis of the main range. It became a subject of frequent observation, as our work extended into the middle and southern portions of the range, that the sedimentaries often reached to within a mile and less of those points where the crystalline nucleus of the range had reached the maximum of upheaval, and this without greatly disturbing the sedimentaries; while at other localities, where there was not apparent cause, indeed where the Archæan rocks do not even show themselves, evidences of some of the most remarkable disturbances were encountered, showing the unequal action of the elevatory forces, especially at the extremities of the great uplift in which originated the range. That the above fold belongs to one of the latter exhibitions there can be little doubt; and hence the unprofitableness of the endeavor, with the limited time at our disposal, to trace the fold southward to any distance, where the elevatory forces seem to have been far more uniformly distributed, as evidenced at numerous points where we succeeded in extending our sections across the range, and where the minor inequalities in the sedimentaries are altogether subordinate to the great displacement.

The outline sketch from Station XXXII exhibits the relations of the sedimentaries to the metamorphics in this northern portion of the range, where the former constitute the highest elevation, 10,300 to 10,500 feet. A little west of south rises the rugged spur which defines the northern border of the wide Archæan area, on the western flank of which rise up the volcanics, as shown in section B of the accompanying plate of sections across the Téton Range. Almost in line with the western promon-

Plate XXXIII.

Sta.

W. Téton Cr. Cañon.



near Station X

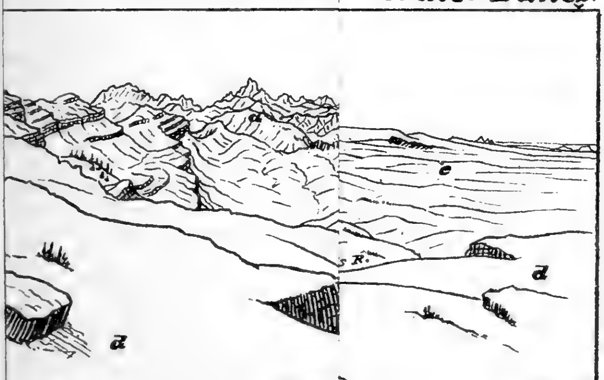
nity of W. Téton Cr. Cañon.

one, etc. f. Volc deposits.

Mt. Moran. Mt. Hayden

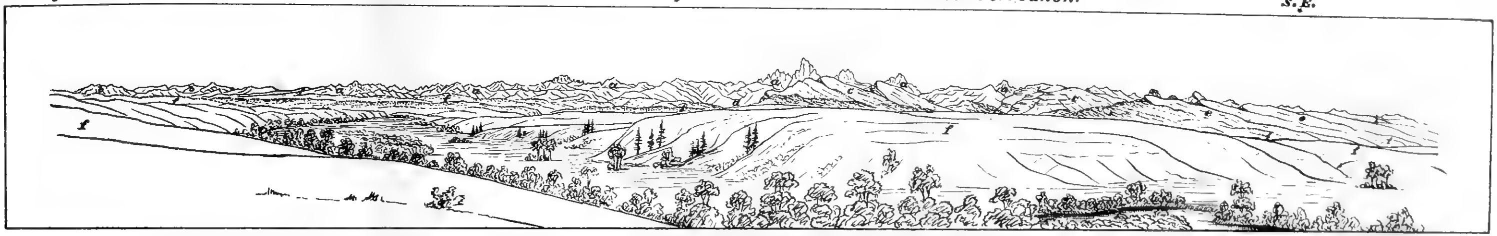
Three Buttes.

Crater Buttes.



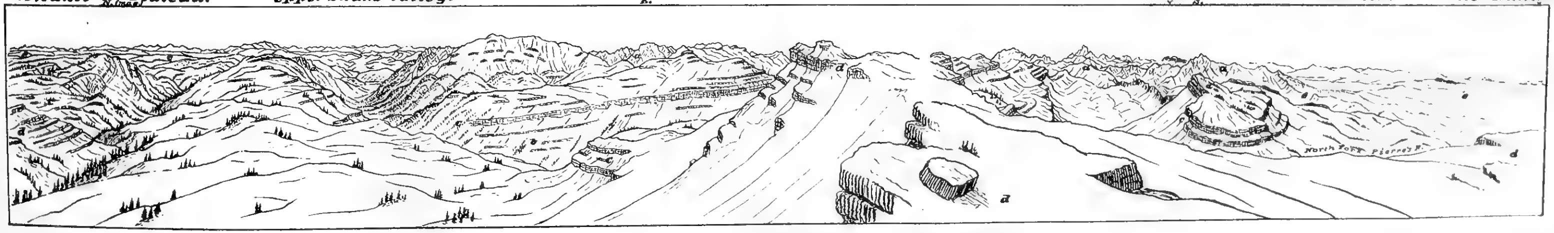
XXXII.

d. Volcanic.



Téton Mountains: From upland north of Pierre's Basin near Station XXXIV on Cañon Creek.

a. Archæan. b. Palæozoic, N.W. flank of range. c. Upraised Palæozoic vicinity of W. Téton Creek Cañon. d. Bear Cr. Cañon. e. Great Foreland south of West Téton Cr. Cañon, Carboniferous red beds—sandstone, etc. f. Volcanic and Lacustrine (?) deposits.



Téton Mountains: From Station XXXII.

a. Archæan. b. L. Silurian. c. U. Silurian. d. Carboniferous. e. Volcanic.

tory of this spur and some 8 miles south, or 13 miles south of Station XXXII, in a high ridge on which Station XXXV was located, the sedimentaries again appear high up on the western flank of the range, defining the southern limits of the Archæan area, and breaking down into a magnificent amphitheatre based upon the rapidly rising metamorphic floor which culminates in the great axial ridge along the eastern border of the range. The section here revealed is reproduced in section C. It shows a great foreland rising up from the level of Pierre's Basin with gradually steepening acclivity, its foot bathed in the volcanics, porphyritic trachytes, to an elevation of 800 feet above the edge of the basin and terminating in successive lines of cliffs and steep taluses of *débris* facing the east. The ascent is over grayish-blue, spar-seamed, cherty limestone, containing abundance of characteristic Carboniferous fossils, the strata inclined at angles of 10° to 20°, W. 25° to 35° N. The descent of the slope is in places so much more considerable than the inclination of the strata that the latter are often carved into great bosses, or gently tilted tables, surmounting the western mountain flank.

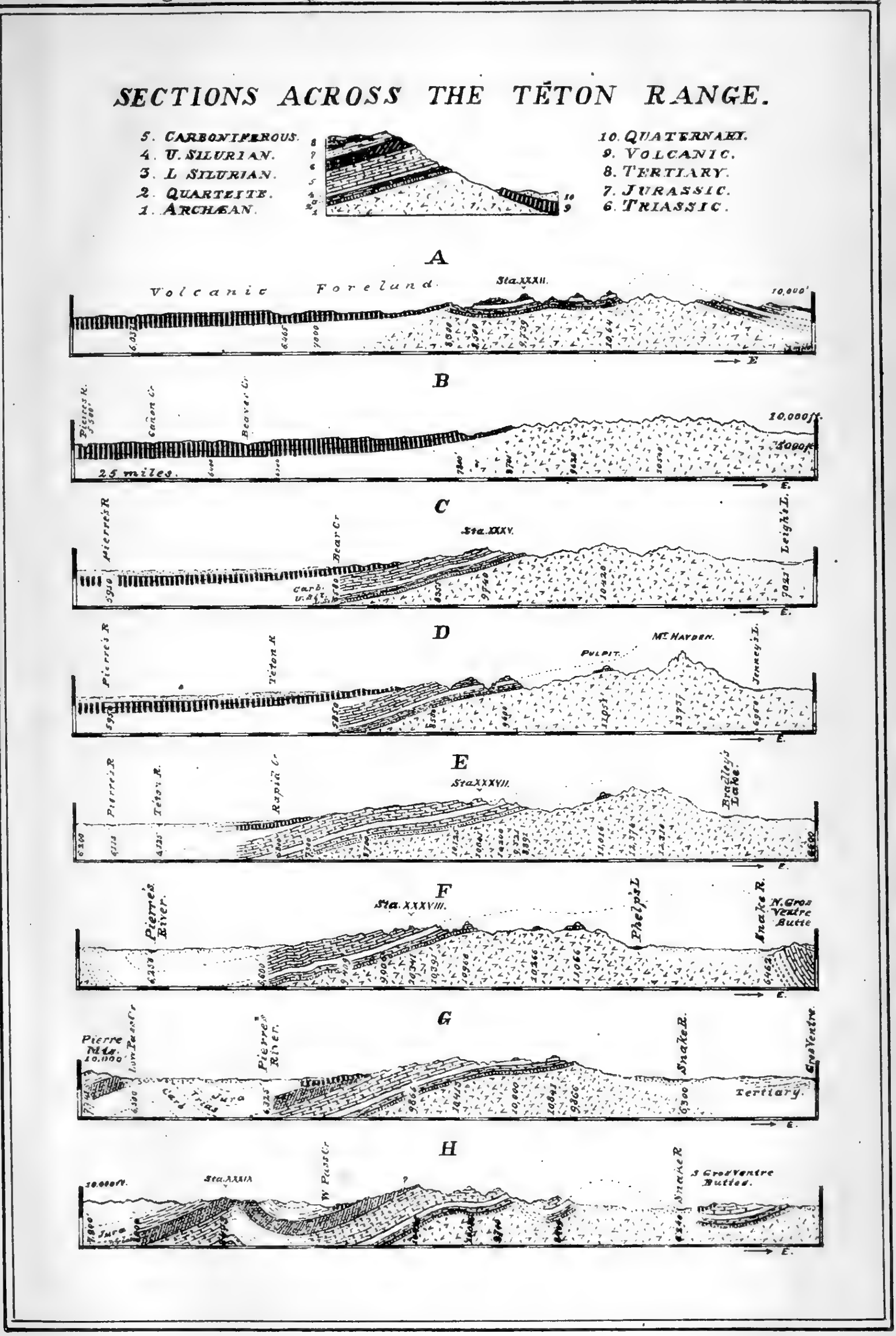
It is very difficult, if not impossible, to obtain a perfect section of these Carboniferous deposits. Even in the abrupt east face, in which the ledges show thin edges, the exposure consists of mural walls of limestone, separated by steep *débris* slopes, arranged in alternating order to a depth which probably includes a thickness of 800 feet of strata overlying the heavy-bedded buff magnesian limestones of the Niagara epoch. Whether these *débris* slopes indicate the position of clay and shaly layers, or the mural ledges only show firmer limestone beds, alternating with more fragmentary and easily degraded strata, was not ascertained; it is, however, probably attributable to both conditions, the more compact beds alternating with both clay and fragmentary limestone deposits. Rising to view from beneath the Carboniferous, the Niagara buff magnesian limestone extends eastward into the Alpine basin like a gigantic pier, often revealing in mural exposures 200 to 300 feet, the base of the cliffs buried in ledge, which is easily recognized by its uniform escarpments, and the *débris* which conceals the total thickness of the formation. This great castellated forms into which its crest weathers, is in turn succeeded by the thinner-bedded, rough, dark drab limestones of the Quebec Group, which rest upon rusty reddish quartzites partially flooring the amphitheatres. Of the Quebec limestones there is seen a thickness of perhaps 300 to 400 feet, the underlying sandstones and quartzites showing about 200 feet more.

Looking northward from Station XXXV, the sedimentaries soon cease, and with them the extreme ruggedness of the surface, which is moulded in the Archæan, which sweeps up in grand, massive ridges, in which the streams have worn comparatively shallow channels. While there is unmistakable evidence here of an excess of upheaval of the Archæan nucleus of the range, by which the sedimentaries were crowded farther to the westward in the region intervening between Leigh's Creek and the North Fork of Pierre's River, the present surface contours are due to the extensive denudation to which this part of the range has been subjected antecedent to the flow of volcanic matter which here rests on the metamorphics, and which has also undergone extensive erosion within comparatively modern times. The volcanics, represented by the ancient porphyritic trachytes which appear in rough, vesicular, rusty ledges and light drab and pink trachytic beds, are traced in more or less well defined benches, which reach an actual altitude of 7,400 feet between Bear Creek and West Téton River, where they gently incline toward the basin. In the debouchure of the latter stream these deposits have been

extensively removed, showing that the valley was probably excavated subsequent to the flow, as there was observed no evidence of the volcanic flow having filled an ancient valley-depression. On the contrary, these deposits may be seen rising in the sides of the present valley, gradually climbing to higher elevations until they reach the above-mentioned altitude, when they cease. It is, however, quite probable that the West Téton Valley was marked out at a time long anterior to the epoch of volcanic eruption, but, as is the case with all the streams on this side of the range, the channel was as yet much less profoundly excavated and opened out in a broad shallow recess facing the basin.

A remarkable feature of the range is its uniformity of outline, and when it is observed that this uniformity holds no relation to the comparative development and position of the rocky materials out of which it was sculptured, it is difficult to conceive by what laws the erosive forces were so evenly distributed as to produce the result embodied in this almost rectangular mountain block, in one part entirely made up of metamorphic materials, in others largely moulded in sedimentary deposits; but the denuding forces have reduced the base to the even line traced by the present western foot of the range, as though it had not to deal with so diverse petrographical elements. The North Fork and Leigh's Creek drainage have constituted the principal channels through which this immense quantity of detrital material was transported and piled up in a wide-spreading accumulation of tailings, to which is doubtless due the low upland that dammed Pierre's Basin, and along which the North Fork flowed, as upon a mole, and which was subsequently involved in the volcanic flows which covered alike all the lower portions of the country. There is scarcely room to doubt that this Archæan area was the theatre of extensive glacial action; but, unfortunately, time did not permit sufficiently close examination to determine its character and extent.

The West Téton River has excavated the largest valley and cañon found on the west side of the range. The lower portion occupies a fine valley half a mile to one mile in width, and for the most part it is filled with level terraces of drift materials, clothed with herbage and margined along the swift-flowing stream by beautiful groves of pine and spruce. Five miles above the debouchure the stream branches, and thence their courses are limited within narrow bounds, until they open out into the Alpine basins which occupy so considerable areas in the heart of the range. Entering the valley from the gentle sloping plain of Pierre's Basin, its debouchure is partially filled with a low morain-like accumulation of loose materials and fine soil, which is hollowed into wave-like inequalities somewhat parallel with the foreland foot, and covered with clumps of aspen. Within the valley huge blocks of limestone and granite bowlders are strewn over the prairie surface and pave the adjacent acclivities, erratics tumbled from the neighboring heights or transported by glacial agencies from the interior portion of the mountains. One of the former, a huge block of Niagara limestone above 5,000 feet cubic contents, rests upon the terrace level a mile or so within the valley, whose transportation from the nearest ledges of its kind could hardly have been effected by other than glacial means. The volcanics show in rusty and brick-red outcrops in the north side a couple of miles within the entrance, where they hold a position several hundred feet above the valley-floor. There appear the Carboniferous limestones, which are soon upraised sufficiently to bring to view the Niagara dolomitic limestones. The latter thence form a line of picturesque castellated cliffs, gradually mounting and reaching to the forks of the stream, in the vicinity of which they sweep round


SECTIONS ACROSS THE TĒTON RANGE.
5. CARBONIFEROUS.
4. U. SILURIAN.
3. L SILURIAN.
2. QUARTZITE.
1. ARCHÆAN.
10. QUATERNARY.
9. VOLCANIC.
8. TERTIARY.
7. JURASSIC.
6. TRIASSIC.
A
Volcanic Foreland
Sta. XXXII.
10,000'
E
B
Pierres R.
Cañon Cr.
Beaver Cr.
10,000 ft.
5000 ft.
25 miles.
E.
C
Pierres R
Bear Cr
Sta. XXXV.
Leigh's L.
Carb.
U. Sil.
L. Sil.
E.
D
Pierres R
Teton R
Pulpit.
Mt. Hayden.
Jenney's L.
E.
E
Pierres R
Teton R.
Rapid Cr
Sta XXXVII.
Bradley's Lake.
E.
F
Pierre's River.
Sta. XXXVIII.
Phelps L
Snake R.
N. Gros Ventre Butte
E.
G
Pierre Mts. 10,000
Pierre's River.
Snake R.
Gros Ventre.
Carb.
Trias
Jura
Tertiary.
E.
H
10,000 ft.
Sta. XXXIX
W Pass Cr
Snake R
S Gros Ventre Buttes.
Jura
E.

to right and left, forming a prominent course in the walls of the amphitheatres into which this part of the range has been sculptured. A fragment of the Niagara still crowns the crest of the huge ridge between the upper main forks of the stream. About midway of the valley-course of the stream, the Quebec limestones appear to view from beneath the Niagara, and gradually rising to the east, at the upper end of the valley they show in two fine escarpments separated by a band of steep talus over an interdeposit of blue clay and shales, the whole making up a thickness of 200 to 400 feet. A similar talus slope constitutes the demarkation between the upper ledge of the Quebec and the Niagara. The slope below the Quebec is broken here and there by outcropping ledges of white sandstone and quartzite conglomerate, probably interstratified with softer deposits above, which make up the lower 200 feet of the sedimentary deposits. The quartzites rest upon the unconformable Archæan, which latter sinks beneath the valley level a short distance below the mouth of Jackson's Cañon. The Quebec limestones and underlying quartzites mount high on the ridge intervening between Jackson's Cañon and the Téton Cañon, and suddenly terminate in the cap of the Pulpit, which immediately overlooks the head of the grand cañon of East Téton Creek. Beyond this the Archæan rises up into the culminating peaks of the range, occupying a belt about five miles in width extending to the eastern foot of the range.

At the forks of the West Téton Valley the Carboniferous limestones have reached a relative elevation of 2,600 feet, where, in the heights in the south angle, 1,000 to 1,500 feet of the inferior portion of the series are seen in successive ledges and hidden bands, underlaid by the Niagara, Quebec, and quartzite, which here exhibit one of their finest exposures. It was in this vicinity Professor Bradley prosecuted his examinations, an interesting account of which is incorporated in the report for 1872. At that time Professor Bradley inferred from their relative position, and partly on account of lithological resemblances, the Niagara age of the buff-gray magnesian limestone, which presents one of the most prominent features in the magnificent exposure of this locality. As previously mentioned, it was our fortune to confirm this identification by palæontological evidence found in connection with this horizon in the northern part of the range. In 1872, Professor Bradley obtained from the inferior drab thin-bedded limestones a few fragments of trilobites, representing species of the genera *Conocoryphe* and *Dicellocephalus*, from which he was able to establish the Quebec age of these lower limestones. He found the Quebec underlaid by compact and shaly glauconitic sandstones, which in turn rest upon a bed of ferruginous quartzite, 50 to 75 feet, the whole estimated at about 350 feet locally, and which were respectively compared to the Knox sandstones of Tennessee and the widely distributed Potsdam. In the lack of facts in the least controverting Professor Bradley's determinations of the stratigraphic equivalents of the above formations, the names which he applied to them have been accepted, only habitually referring to the arenaceous inferior deposits, both sandstones and quartzites, under the term Potsdam, or simply quartzite. During the brief time we spent in the vicinity, the lower or Quebec limestones were found to form two distinct horizons, separated by a deposit of blue clay and shaly layers, the upper bed the thickest, and together making a thickness of 200 to 400 feet.

A section in the south side of the West Téton Valley to the forks, thence passing over the partially Quebec-capped ridge between the north branch and Jackson's Cañon to the Pulpit, and thence by Mount Hayden to the eastern foot of the range, along a nearly east-west line, is shown in the

accompanying plate, Section D. This profile exhibits approximately the relative position and present distribution of the sedimentaries in this part of the range.

South of the West Téton Valley, a huge tilted block of the sedimentaries, four to five miles in breadth, constitutes the west flank of the mountain between that stream and Goodfellow's Creek, on the southeast angle of which Station XXXVII was established. The eastern face of this ridge is wrought into amphitheatres and colossal pier-heads, on the one hand extending out into the granite-floored Alpine Basin in which West Téton Creek rises, and on the other the smaller basin at the head of Goodfellow's Creek, which is also based on the light-colored granite, from which rise ridges capped by remnants of the more ancient sedimentaries. The latter basin is bounded on the south by a line of steep acclivities with precipitous coping of Silurian limestone, which culminates in a lofty isolated mountain, having the semblance of a huge architectural pile, nearly 11,000 feet in actual altitude, to the southeast and east of which the axial crest of the range swings round in broad-topped summits bearing characteristic remnants of the quartzite and Quebec. The section here displayed is very like that previously described, as a comparison of Sections D and E will render apparent. The latter section is also carried across the range along a nearly east-west line.

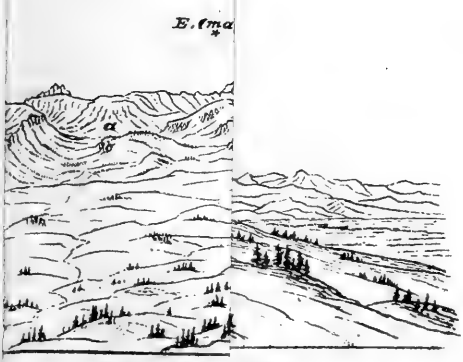
The volcanics reach an elevation of between 500 and 800 feet along the west foot of the mountain, and at about 1,000 feet are succeeded by ledges of buff-red hard sandstone. The latter continues to hold its place in the wooded ascent, whose inclination apparently closely corresponds to, as it is determined by, the dip of the sandstone pavement to a point about four and a half miles from the edge of Pierre's Basin, where they terminate in a range of steep bluffs which define the west side of lateral gulches draining into the West Téton. In the higher parts of this bench a section of 300 to 500 feet vertical thickness is more or less well exposed, the upper portion of which shows a handsome, even-bedded, reddish-buff, laminated sandstone, which forms a heavy bed, including a thick stratum of intensely hard, rough, rusty-gray rock resembling burr-stone, which in places forms the coping. This bed is underlaid by an equal or greater thickness of red and chocolate-brown indurated arenaceous shales, interbedded with light-drab, sometimes nodular, shaly, non-fossiliferous limestone and deep-red laminated sandstone, making up the lower third of the bluff exposure. The above deposits rest conformably upon bluish-gray and drab limestone, containing a small Zaphrentoid coral and an obscure *Spirifer*, and which forms the top of the Carboniferous limestone series; dip, 10° to 15°, northwestward.

The saddle connecting the above bluff with the ridge of Station XXXVII, a mile to the east, is paved with the limestones, of which about 500 feet are exposed in the abrupt declivity in which the eastern face of this ridge breaks down. In the summit at Station XXXVII the upper layers of dark-drab limestone dip at angles of 15° to 20° westward, and is underlaid by gray and buff cherty limestone with calcite, and containing a *Lithostrotion* (*L. Whitneyi?*) and a form of *Syringopora*. This ridge is blocked out of the Carboniferous limestones, and the narrow gulch which separates it from the next west-lying sandstone ridge is floored with large exposed surfaces of the rock, which are here and there obstructed with sink-holes, and on the lower side pretty little lakelets are hollowed out of the soft red deposit at the foot of the bluff. When the rapidly-descending gulches reach the horizon of the heavy-bedded Niagara, their beds are precipitated several hundred feet down steep slopes, which, earlier in the season, when the streams are full from the

Plate XXXV.

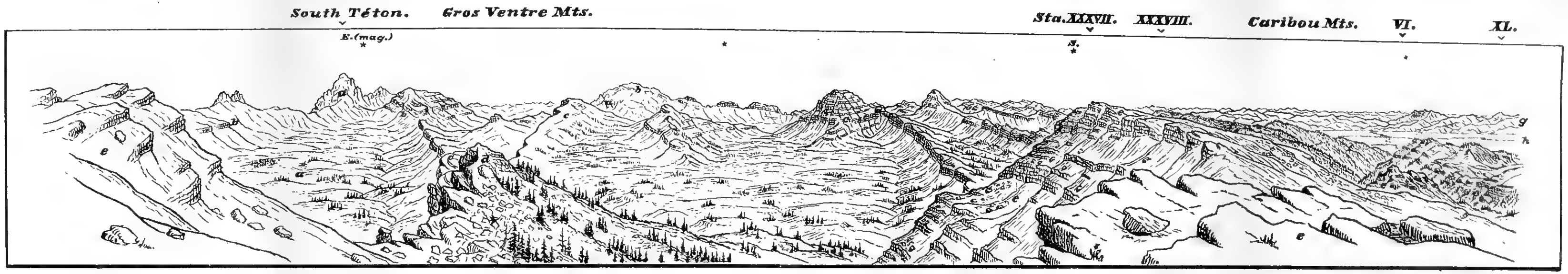
rom Stat

f. Carb. re



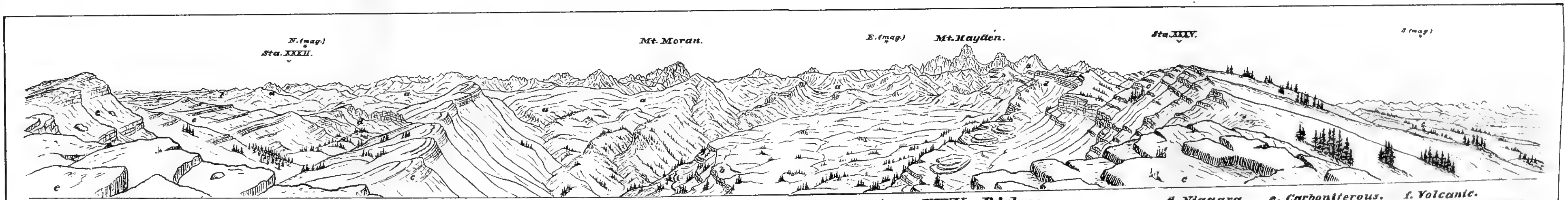
om Statio nic.

Pierre's Basin.



West Téton Creek. **Téton Mountains: From Station XXXVII ridge.** Goodfellow's Cr. Cañon.

a. Archæan. b. Quartzite. c. Quebec. d. Niagara. e. Carboniferous. f. Carb. red beds. g. Snake River Mountains. h. Pierre's Basin.



a. Archæan. b. Quartzite. c. Quebec. **Téton Mountains: From Station XXXV Ridge.** d. Niagara. e. Carboniferous. f. Volcanic.

Volcanic Watershed. Bear Creek. Snake River Range. Pierre's Basin.

melting of the snow-drifts, must present many wild, picturesque cascades.

The east face of Station XXXVII ridge drops down in precipitous slopes over the Carboniferous beds to the buff heavy-bedded magnesian limestone of the Niagara, which here occurs in characteristic escarpments, its foot often buried in *débris*. Beneath the latter successively appear ledges of the dark thin-bedded Quebec limestone, underlaid by rusty yellow and red deposits pertaining to the quartzite horizon, which mount higher and higher as they advance towards the summit of the range, where they crown massive Archæan heights with low parapets and *débris* caps. The view from this point is very grand and instructive, opening as it does something like adequate conception of the slow-operating forces which have reduced the great uplift to its present diverse aspects. To the north we always overlooked a field in which the Archæan rocks form a prominent element; but in this quarter we are able to form a more just conception of the agencies by which those more finished results were attained, and a measure of the progress of these forces in the degradation of the immense superficial covering of sedimentary rocks which originally roofed the whole range alike. While to the north of West Téton Creek the crystalline rocks cover broad areas of the crest and flanks of the range, where not only the mantle of sedimentary deposits has been swept away to the last vestige, but the crystalline core has been deeply eaten away; here the granites outcrop in circumscribed basin-areas, which retain almost the original contour of the surface upon which the once continuous sedimentaries rested, while the latter, indeed, occur everywhere; here in isolated islands, there in gigantic outlying masses which hitch on to the great escarpment of the western foreland, by a system of rugged connecting ridges whose distruction is hardly half consummated. There can be no doubt that the northern portion of the range has been subjected to much greater denudation than the southern portion; but whether this indicates the greater time period during which these forces have operated in the one quarter, or a less violent manifestation of their action in the other, we shall endeavor presently to determine.

The maximum elevation of the range probably culminated in the vicinity of Mount Moran. It is reasonable to suppose that in this part of the uplift the more fragmentary sedimentary covering was subjected to greatest tension and consequent fracturing, by which these rocks were here broken up, yielding more readily to the denuding agencies than would be the case in less disturbed and lower portions of the range. Hence, it is apparent that the area of greatest denudation corresponds to that of greatest elevation; and that, if the degrading agencies concerned in the work of demolition have operated the same period in all parts of the range, their work progressed with greater rapidity in those portions where the rocks were most fissured and accessible to the elements combined in their destruction and transportation to the lowlands. It is, to say the least, premature, in the present state of knowledge, to discuss the forms in which the denuding forces were embodied which carved mountains out of the sedimentary strata and planed down the granitic nucleus. To what extent ice, in the form of glaciers, has acted in this work we have only a few and far too insufficient data upon which to build more than a conjecture, while, on the other hand, the ordinary atmospheric effects of freezing and thawing, and water erosion and the work of streams, are visible on every hand, the same to-day as in ages past. There can be little doubt that special research in these mountains will yet bring to light abundance of glacial phenomena; but whether to this source alone are to be attributed the origin of the wonderfully diverse

erosive phenomena here encountered, the fashioning of the Alpine basins and the cutting of the cañons through which their gathered waters flow to the plain, may well be questioned.

To the south still, a similar but much norrower tilted table lies between the cañons of Goodfellow's and Fox Creeks, the geological features of which are a repetition of what has already been described. On the southeasternmost angle of this great upraised block of sedimentary rocks Station XXXVIII was established, four miles south-southwest of the preceding topographic station. This point commands, on the northeast, a circumscribed basin at the head of a branch of Goodfellow's Creek, which is quite surrounded by the sedimentaries, which form a broken rim of variable height, sustained by accumulations of *débris* which slope steeply to the bared and glaciated white granitic floor. The western rim sweeps up into the abrupt acclivities capped by several hundred feet thickness of the Carboniferous limestones; to the right and left great arms are extended eastward and united in a lofty summit nearly 11,000 feet in height, which inclose the basin within a wall of Lower Silurian deposits.

Fox Creek opens out into a similar basin to the southeast of Station XXXVIII, which, however, is mainly floored by the quartzite, with remnants of the Quebec limestones standing as isolated buttes and tables which reach quite across to the eastern summit verge of the range, the main channel of the stream only apparently hemmed in by steep Archæan acclivities.

The immediate crest of Station XXXVIII ridge is formed of the Carboniferous limestones, which afford the usual organic evidence of their age. These are immediately overlaid by a series of deep red arenaceous shales and sandstones, holding interpolated beds of nodular and fragmentary drab and chocolate-stained limestone, capped by a heavy deposit of buff and pale red even-bedded sandstone and the burr-stone ledge, which constitute the roof of the great foreland descending into Pierre's Basin. The relative position of the strata here mentioned is shown in section E, which is carried across the range through Station XXXVIII along an east-west line.

To the south and southeast of Station XXXVIII the summit of the range presents a marked change in its geologic and concomitant topographic features. It exhibits a wilderness of huge sedimentary ridges, piled one above another, advancing towards the east, where they are suddenly broken down in long lines of steep and, in places, precipitous slopes, with here and there a headland, like gigantic breakers transformed into stone. The range is thence enveloped in these rocky surges, which finally lap completely over the crest and eastern flank in the vicinity of the southern extremity of the range, hiding from view the nucleus of Archæan rocks. From the remnants or isolated exposures of the Palæozoic series in Jackson's Basin, on the east side of the range, we infer, with some degree of confidence, the colossal proportions of the rocky billows that once spanned the southern half of the great uplift out of which the Téton Range was carved, and in comparison with which those folds which remain visible to this day are mere undulations. It is greatly to be regretted that opportunity was lacking to penetrate to the summit of the range in the portion intervening between Station XXXVIII and the high point at the extreme south end, which was selected for the final topographic Station, XLIII. Consequently, we are left somewhat in doubt regarding the special expression, so to speak, of the disturbances which here transpired, and the records of which are to be sought in something more than hastily-executed examinations. Therefore, in giv-

PLATE XXXVI.

Téton Mountains: Amphitheatre at head of Goodfellow's Creek, from Station XXXVIII ridge.

Téton Mountains: From Station XXXVIII ridge north of Fox Creek Cañon.

a. Archæan. b. Quartzite. c. Quebec. d. Niagara. e. Carboniferous. f. Carb. red sandstone, etc.

ing the final transverse section of the range, section G, the facts observed, as in the preceding diagrams, are readily distinguishable from the inferred.

The western flank of this portion of the range is apparently precisely similar to what obtains in the blocks between Fox Creek and the West Téton Valley—a great foreland covered by the sandstone and red arenaceous deposits, which here constitute the uppermost member of the Carboniferous. But while this block terminates in precipitous declivities facing the east, it is here succeeded by loftier and almost equally massive ridges, which appear to rise up from beneath the foreland block in a succession of great billows with which this portion of the range is furrowed. It is also rendered apparent that these ridges are stratigraphically alike; that is, they are all composed of the same series of strata, which were once spread out in horizontal layers on the bottom of the sea, and to account for their present position, fortunately, we are not wholly without evidence that furnishes a clue. As seen from the Lower Gros Ventre Buttes in Jackson's Valley, the east wall of the range rises rapidly over 1,000 to 2,000 feet of Archæan ledges, which are capped by more than as great again thickness of sedimentary formations. The latter, at one point, a little south of west of the confluence of the Gros Ventre with the Snake River, are projected in a sharp-crested, bastion-like ridge a distance beyond the lofty axial summit, and where they plainly exhibit one of the sharp subordinate undulations into which the great primary fold of the range was corrugated. The western flank of a similar, if not identical, secondary fold is preserved in the outlying hill in the north angle of the debouchure of East Pass Creek, a few miles south of the above-mentioned exposure, in which the Carboniferous limestones are seen dipping gently into the range, or W. 35° N. at an angle of 14°. The same beds again appear in the Lower Gros Ventre Buttes, where they were observed by Professor Bradley, in nearly horizontal position.

Ascending East Pass Creek, which flows through a wild, thickly-wooded ravine, no ledges *in situ* are met with adjacent to the trail until approaching the summit of the pass, where we encounter the upper silicious horizons of the Carboniferous. About midway, large masses of buff, rough-weathered, magnesian limestone, more or less abraded, appear in the steep slopes, indicating the presence of the Niagara beds in the depression between the outlying hill and the main mountain. And higher up, perhaps a couple of miles from the summit, quantities of abraded boulders of gneiss, schists, and other Archæan rocks are met with, which doubtless were brought down by the streams which penetrate the range to the north.

On descending West Pass Creek, a mile or so west of the summit and but little lower in elevation, the trail crosses a spur ridge in which is exposed a considerable thickness of deep red, even-bedded sandstone and sandy shales, dipping at an angle of about 45° southward, and which probably represent the "red beds" of the Trias. These deposits continue for a distance of several miles; even where the ledges are unexposed their position is marked by the luxuriance of herbaceous growth so characteristic of the slopes underlaid by or composed of the *débris* derived from these deposits, as observed at many other and distant localities in this region. Between three and four miles below the summit the main valley receives on the right a deep gulch which heads between Station XLIII and its higher neighbor to the northwest. In the lower angle of this gulch the steep mountain side is plated with heavy ledges of Carboniferous limestone dipping steeply to the southwest, but gradually slackening in inclination as they rise higher in the mountain. The

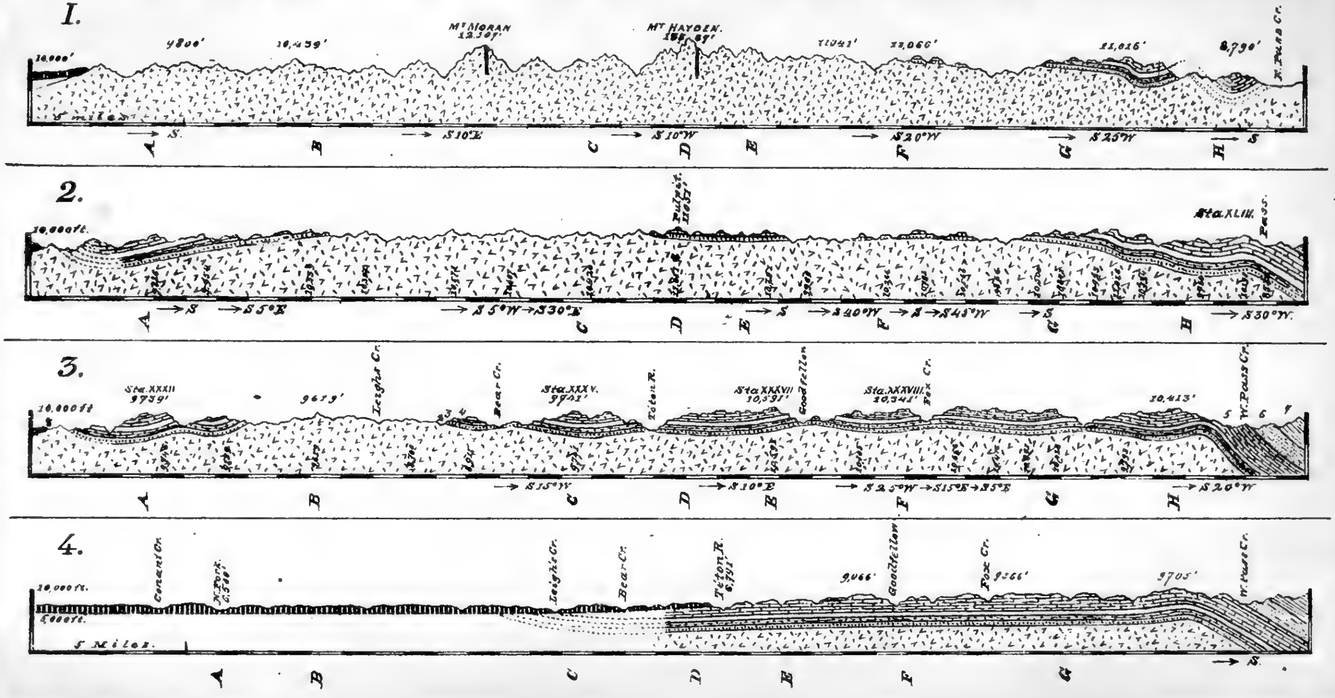
valley here shows much limestone *débris*, among which occur heavy masses of gray siliceous rock which have tumbled from ledges above. The latter also probably pertains to the Carboniferous, representing the upper siliceous horizon.

Just below the last-mentioned locality the valley widens, giving room for the narrow intervale which continues thence to the debouchure into Pierre's Basin, its surface willow-grown and the little brook converted into a chain of pools by beaver-dams. Again the "red beds" set in, overlaid by drab shales and shaly and compact drab, spar-seamed limestone, with obscure exposures of brown-weathered limestone, which bear unmistakable resemblance, lithologically, to the Jurassic deposits elsewhere encountered in the district. These are in turn succeeded by softish gray thin-bedded sandstones, exposed in low *débris*-covered slopes two or three miles within the mouth of the valley, below which the vesicular dark-brown porphyritic and drab and pink trachyte volcanics reappear, extending thence out into the borders of Pierre's Basin. The water-worn *débris* so plentifully occurring in the valley is composed of red sandstone and gray siliceous and drab limestone bowlders, the absence of Archæan erratics being a notable fact and showing that none of the water-courses at the southwest extremity of the range have eroded their beds to the crystalline basis upon which the sedimentary formations rest. This is an extremely interesting little valley, abounding in picturesque scenery; on the one hand, the steep rocky acclivities which rise into the dominating peak at the extreme south end of the range, deep gorges opening short vistas into the mountain, their beds a chaos of tumbled rocks; on the other, lower and more gentle ridges, densely wooded with beautiful forests of pine and spruce, rise, rank upon rank, into the broken mountain region included in the great bend of Snake River.

It is quite apparent that for at least a few miles north of West Pass Creek, the foot-hills along the west flank of the Téton Range are made up of the Triassic "red beds" and Jurassic deposits overlaid by a remnant of the peculiar soft gray sandstones which have elsewhere been provisionally referred to the Laramie Group. But these are soon replaced by the siliceous beds and limestones of the Carboniferous period, which rise up into the Twin Mountains at the extreme south end of the range, on the easternmost of which Station XLIII was located at an actual altitude of 10,193 feet, or 1,663 feet above the summit of the pass, a mile to the south. The southern declivity of the latter eminence is heavily mailed with Carboniferous limestone more or less cherty and spar-seamed, which dips 47° S., 40° W. The foot of the slope in the immediate vicinity of the saddle is made up of the buff siliceous deposits whose *débris* strews the surface, while on the summit of Station XLIII lower limestone horizons are reached, charged with *Zaphrentis* and large masses of *Lithostrotion*, *Spirifer*, several species of *Productus*, and a small *Athyris*. These summit strata show a variable degree and direction of inclination, ranging from 5° to 25°, W. 25° to 60° N., the beds actually folding partially around the mountain from a northwest to a southerly direction. The same is also observed in the higher mountain two and a half miles to the northwest, whose escarped southeast face shows the strata nearly level along the northeast and southwest line of strike, while on the southern flank they pitch down rapidly into West Pass Creek Cañon. It seems highly probable, also, that the saddle between these mountains occupies the position of a synclinal of one of the secondary folds with which this portion of the range was wrinkled.

A section in the ridge of Station XLIII, presents very nearly the

SECTIONS ALONG THE AXIS AND WEST FLANK OF THE TÉTON RANGE



same stratigraphic features as noted previously in the vicinity of Stations XXXVIII and XXXVII to the north. The summit drab limestones are overlaid, in the crest of the ridge a short distance northwest of the summit, by a thickness of 150 to 200 feet of strata, which show the following order of arrangement;

Section in crest of Station XLIII ridge.

a. Hard, pinkish gray, laminated sandstone, 50 to 75 feet exposed.
b. Blue and gray limestone, with crinoidal remains; dip W. 35° N., angle 23°.
c. Reddish chocolate, fragmentary limestone, *Spirifer* and comminuted fossil remains; thin bed.
d. Red shale and shaly sandstone, with dark flint flakes.
e. Rough, cherty, gray limestones; thin bed.
f. Laminated, gray-buff, reddish stained sandstone, forming a heavy bed capping the ridge at one point.
g. Drab-blue limestones; thin bed.
h. Red shales and sandstone.
i. Drab-gray limestones, exposed 400 feet and more in steep slopes descending into amphitheatre.

The above ledges veer round in the crest of the ridge defining the amphitheatre which opens out to the east, the uppermost sandstone appearing in the slope descending to the saddle connecting this ridge with the higher mountain to the west. In the summit of the latter is plainly seen a remnant capping of dull reddish beds, which may possibly prove to be identical wlth the red arenaceous horizon above described, rather than referable to the base of the Trias "red beds." The southeastern face of this mountain shows a fine exhibition of the Carboniferous limestone ledges, 800 feet or more in thickness, and which, as before stated, curve round from the northwest to the south where they abruptly dip in the steep slopes bordering West Pass Creek. The accompanying sketch conveys at a glance the relative position of the strata in the latter mountain, as seen from the south flank of Station XLIII, the difference in altitude of the two mountains being about 220 feet.

Looking northward from Station XLIII, the eye takes in at a glance the great sedimentary ridges which here span the range, terminating in the chain of lofty summits which crown the eastern barrier, which abruptly descends into Jackson's Basin. The western foreland here, as farther northward, terminates in ridges whose eastern face falls away in a succession of escarpments and steep slopes into amphitheatres in which the west-flowing streams take their rise. But in this section the amphitheatres are much restricted, and the drainage channels are cañoned in the sedimentary deposits, rarely, indeed, cutting their beds through to the Archæan basis, which only appears in force in the mountain wall rising from Jackson's Basin. While in the north the continuity of the sedimentary beds may be traced for miles in the foreland escarpments and in the great pier-like ridges separating the Alpine basins, in the latter region these same deposits are thrown into an assemblage of rugged ridges and mountain blocks which almost defy the recognition of the various formations from any one point of view over so extensive and broken a field. This is mainly due to the fact that these deposits are much disturbed by minor and more or less local undulations, which, in comparatively short distances, cause the same beds to appear at very different relative levels, while the repetition of similar lithological condi-

tions greatly perplexes and confuses the study and identification of synchronous strata in the various parts of the field in view.

About midway between the southern end of the range and Station XXXVIII, or some five miles north of Station XLIII, the Carboniferous first reaches the eastern front of the range. It here caps the cliffs of Niagara limestone, in the heights about northwest of the Lower Gros Ventre Buttes, where the latter is in turn underlaid by the low escarped Quebec ledges, from beneath which the rusty and yellow deposits of the quartzite horizon also appear, gradually sinking to the south, until all disappear, save the Carboniferous which forms the foot-hills in the immediate vicinity of East Pass Creek.

In further explanation of the geological structure of the Téton Range, attention is directed to the longitudinal and transverse sections given in an accompanying plate, which convey a tolerably accurate view of the profile of the range along the lines of the sections. The drainage map, reduced from the topographic sheets, exhibits the general distribution of the geological formations so far as it was possible to make them out in the course of a necessarily brief visit.

SNAKE RIVER RANGE.

Under the general term Snake River Range is included the belt of highlands to the west and south of the Téton Range, which has a general northwest and southeast course of about sixty miles within this district, ranging from twelve to twenty miles in breadth. Towards the southern border of the district the Snake River has forced a narrow passage through the range, which is known as the Grand Cañon, where for a distance of about twenty-five miles the stream is confined between mountain walls, with little or no intervale room. In the vicinity of the Grand Cañon the highland belt occupies the whole area between the upper and lower course of the Snake, and where it reaches its greatest breadth. On the northeast it impinges against the south extremity of the Téton Range, and thence northwesterly it gradually narrows and finally merges into the volcanic upland south of the western course of Pierre's River.

The Snake River Expedition of 1872 further distinguished this mountain belt by local appellations, which, if not absolutely of topographical importance, may be accepted for the convenience of descriptive purposes. To the north the range culminates in a series of peaks and high ridges, the highest of which attain an absolute altitude of 10,000 to 10,420 feet, to which the name Pierre's Mountains has been given. About fifteen miles from the northern extremity of the range, it is traversed by a low sag, which opens an easy passage across from Pierre's Basin to the lower valley of the Snake, the southwestern flank opening into an extensive rugged basin area which drains out into the Snake but a few miles above its debouchure into the great plains. To the south of this low pass lies an equally if not more rugged low mountain region, which fills the great bend of the Snake and passes southward into the adjacent district, finally dying out in the watershed between the Green and Bear River Basins. That portion of the latter section of the range nearest the southern end of the Téton Range has received the name Téton Pass Mountains, and which may be understood to embrace a narrow mountain belt extending from the head of Pierre's Basin in the vicinity of the Low Pass, southwesterly to the Upper Snake, in the region of the foot of Jackson's Basin, or above twenty miles in length. The highest eminences in this latter mountain-belt do no exceed 9,500 feet, but to the south the highlands culminate in more lofty summits, whose isolation rather than actual alti-

tude renders them conspicuous landmarks, notably so in the instance of the almost perfect cone of Mount Baird, which rises in the heart of the broken region in the great bend of the Snake.

That portion of the range to the north of the Grand Cañon closely follows the valley course of Snake River, where, as seen from the west bank of the river, it presents an exceedingly rugged and imposing mountain wall, cleft by the narrow valleys which give exit to the interior drainage. To the south of the Grand Cañon, as far as could be seen, it is continued in an almost equally formidable barrier, which is traversed by the defile of John Day's River in nearly the direction of the trend of the range. Between the latter stream and Salt River, farther south, lower ridges intervene, which Dr. Peale found to be made up in part of Mesozoic strata. The main barrier fronting the lower valley of the Snake, according to Professor Bradley, is mainly if not entirely composed of Carboniferous deposits, and, judging from the resemblance of the harder ledges in the lower or northern extension of this western front, the same formation would appear to constitute the bulk of the mountain wall throughout. Even from the distant view with which we were compelled to content ourselves, it was evident that this front ridge partakes in some measure of the excessive disturbance which was found to characterize the eastern portion in the regions of the Pierre's and Téton Pass Mountains, the strata in places rising in the steep slopes like a rocky mail, elsewhere showing their edges dipping away from the valley or northeast; their foot, from a point about half way between the debouchure of the Snake and the lower entrance of the Grand Cañon, being enveloped in the volcanic deposits which reach up the valley from the plain.

PIERRE'S MOUNTAINS.

Such opportunities as I possessed allowed only a partial examination of this most interesting region, and this was mostly confined to the Pierre's Mountains on the western border of the basin of the same name. Viewed from the basin-plain, the eastern front of these mountains presents a series of more or less regular spur-ridges, which gradually rise up into the eastern mountain-crest, and which are much complicated by secondary spurs due entirely to the erosive action of the short drainage channels which flow out into Pierre's Basin. The principal spurs, however, conform to the strike of the strata, and hence have a general northwest and southeast direction. One of these ridges forms the water-shed of the drainage which flows into Pierre's Basin on the one hand, and on the other is drained into the lower valley of the Snake through the stream which gives exit to the waters collected in the mountain-basin west of Low Pass. Pursuing a northwesterly course, it culminates in a high point, on which Station XL was established, at an altitude of 10,100 feet above the sea, or a relative elevation above the level of Pierre's Basin of about 3,800 feet. It forms a monoclinal ridge of Jurassic beds, dipping to the southwest at varying angles of inclination, and much broken by the drainage channels which intersect it from either side. For a large part of the way the ridge is capped by a heavy ledge of quartzite, beneath which occur more or less distinct exhibitions of sandstones, drab limestones, and shaly deposits. On approaching Station XL, the latter are seen to rest upon a heavy accumulation of deep red arenaceous shales and sandstones, which form a wide belt of brilliant color in the northeast face of the ridge. These are succeeded below by buff-red siliceous beds and intercalated limestones, which finally pass into the usual drab and gray cherty limestones everywhere making up the lower measures of the

Carboniferous in this region. A section, starting on the well-determined Carboniferous limestones and carried along a southwest and northeast line, or nearly at right angles to the strike, across Station XL ridge, is shown in an accompanying plate. As this section affords what may be regarded as a typical exhibition of the stratigraphic structure of a series of formations which constitute an important element in the geological history of the region, a detailed description is here appended.

Section through Station XL.

1. Gray and drab, cherty, spar-seamed Carboniferous limestone, exposed in south flank and crest of high ridge north of Station XL ridge, the southeast continuation of Station XLII ridge.
2. Reddish-buff sandstone, imperfectly exposed in south side of saddle.
3. Gray limestone ledge.
4. Very hard, flinty, gray sandstone, almost a quartzite. Dip 40°, S. 45° W.
5. Light gray, slightly siliceous limestone, with chert bands.
6. Hard reddish buff-gray sandstone.
7. Gray siliceous limestone.
8. Reddish buff-gray sandstone, with dark flinty fragments and hard gray siliceous layers.
9. Dark chocolate-colored and rusty indurated deposits, obscurely exposed in shallow saddle.
10. Gray, cherty limestone, containing a large *Bellerophon*, and *Dentalium?*
11. Hard reddish-buff sandstone.
12. Drab limestone.
13. Very hard fragmentary light-buff sandstone.
14. Very hard grayish sandstone.
15. Hard rusty-brown laminated sandstone.

16*a*. Dark blue shales and indurated layers.

16*b*. Reddish shales and rusty-gray indurated layers.

17. Dark drab, thin-bedded limestone, with *Lingula*, small *Pleurohorus?*
18. Rusty and gray, fine laminated, indurated argillo-arenaceous deposits.
19. Reddish shales and indurated layers, exposed in saddle and ravine north of Station XL.
20. Tough gray sandstone, dark brown stained on exposed surfaces, with obscure indeterminate Lamelli branch. Dip 44°, S. 50° W.
21. Gray and rusty indurated layers.
22. Hard, gray, rusty-buff weathered sandstone.
23. Gray limestone, thickness of 10 feet exposed.

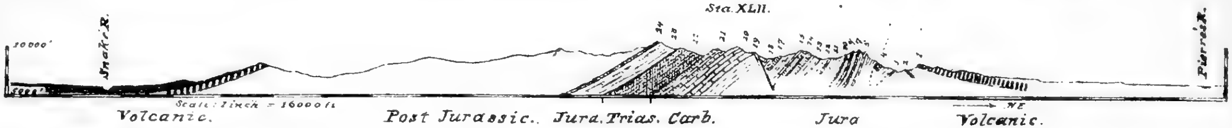
24*a*. Drab indurated arenaceous shales.

24*b*. Red shales.

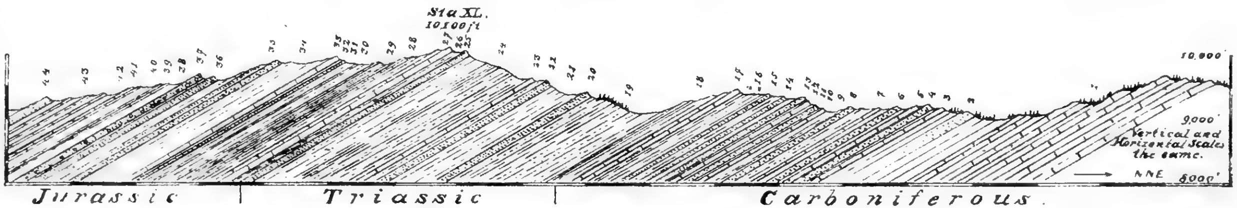
24*c*. Deep red arenaceous shales and indurated layers forming a prominent belt of brilliant red exposures inthe north slope of the mountain.

25. Hard, pale red or pink, sandstone, 75 feet, more or less.
26. Reddish shales.
27. Grayish or dark drab, in places buff-mottled, spar-seamed, fragmentary limestone, forming a heavy ledge, 40 feet or more in thickness, in crest of Station XL ridge; dip 40°, S. 50° W. This ledge contains a few imperfectly preserved fossils, among which are recognized crinoidal fragments which may prove to be *Pentacrinites*, a largish smooth Lamelli

Profile across the north end of Pierre's Mountains, through Station XLII.



Section across Station XL ridge, Pierre's Mountains.



Profile across Pierre's Mountains (Snake River Range), through Station XL.

branch which, but for its greater convexity, resembles *Camptonectes*, and a small indeterminate Gasteropod.

28. Drab shaly limestone.

29. Dark chocolate-colored shales.

30. Mainly light drab, indurated, marly shales, with thin bands of drab shaly limestone, forms a heavy deposit. A small *Gryphæa* (*G. Calceola?*) occurs in great abundance in the middle and upper part of the bed.

31. Hard, indurated grit bed, 5 to 10 feet.

32. Chocolate-mottled indurated deposit, 30 to 50 feet.

33. Dark blue and gray, laminated, gritty limestone, a heavy bed, 20 to 40 feet. Dip 37°, S. 45° W.

34. Unexposed space, toward top light drab deposit.

35. Dark and light gray, very hard sandstone, overlaid by dark bluish-gray very hard gritty layers.

36. Dark and buff gray coarse-grained sandstone, with hard pink laminated layers and dirty yellow and brownish soft layers above; 50 to 75 feet exposed. Dip 44°, S. 50° W.

37. Rusty-brown, gray, and reddish conglomerate, and laminated, cross-bedded, very hard sandstone, forming a conspicuous heavy ledge, of which a thickness of 25 feet is exposed, dipping S. 60° W., at an angle of 45°. The pebbles are rounded and arranged in more or less regular layers, and the whole bed is transformed into an intensely hard quartzite, whose rugged outcrop may be traced for miles, and is the same ledge that crosses the spur-ridge in the vicinity of Low Pass on either side.

38. Dull red shales, 40 feet, more or less.

39. Alternations of drab limestone and chocolate-colored sandstone, 40 feet, more or less.

40. Chocolate-red shales and indurated sands.

41. Light drab limestone and interbedded shaly layers.

42. Chocolate-colored shales and gritty layers.

43. Drab shaly and bluish limestones, interbedded with drab shales, forming a heavy deposit several hundred feet in thickness.

44. Reddish buff-gray hard sandstone, a heavy ledge.

The base of the section rests upon the lower limestones of the Carboniferous series, succeeded by the upper siliceous member of the same series, which here attains a thickness of above 2,000 feet between beds No. 1 and No. 18, inclusive. The fossils of bed No. 10, although at present not specifically determined, clearly belong to Carboniferous types. But in the instance of those obtained from bed No. 17, which on account of the imperfect state of their preservation as also the fact that they belong to less characteristic genera, there is room for doubt in the determination of the equivalency of the strata in which they occur. The *Lingula* could hardly be admitted in evidence in so important a question, but the little Lamilli branch certainly bears a striking resemblance to a species of *Pleurophorus* prevalent in Permo-Carboniferous horizons in the region of the Lower Missouri. This fact, if not actual specific identity, in connection with the stratigraphic position of the ledge, which lies immediately below the Triassic "red beds," strongly favors the reference of these upper beds to the horizon of the Permo-Carboniferous. As is generally supposed in the case of the Lower Missouri region, there may be no well-defined demarkation, either lithological or paleontological, separating these upper beds from the distinctively Carboniferous horizons; but taking into account the prominent lithological characters of the latter deposits, they are distinguished in a marked manner into upper siliceous and lower

limestone members, which apparently possess these distinctive features over large areas in this region.

The "red beds" here, also, present what may be regarded as their full development, reaching a thickness of about 2,500 feet, beds No. 19 and No. 26, inclusive, of the foregoing section. They are made up almost entirely of red arenaceous shales and standstones, including just above the middle a stratum of limestone. The Jurassic is introduced by the limestone bed No. 27, in which were observed a few fossils, none of which, however, were sufficiently perfect for identification, although they certainly possess Jurassic *facies*. But in the superimposed indurated calcareous shales the abundant prevalence of a little *Gryphæa*, allied to *G. Calceola*, plainly identifies the horizon with the Jurassic as elsewhere characterized in the northwest. The vertical limit of the Jurassic deposits at this locality was not definitely determined. In the neighborhood of 1,200 feet above the base, a series of hard sandstone beds are met with, capped by a heavy bed of conglomerate, attaining a thickness of about 500 feet, beds No. 35 to No. 37 inclusive. These are succeeded above by a heavy deposit several hundred feet in thickness, consisting of alternations of pale red and chocolate-colored shales and drab limestones with drab shaly partings, which afforded no organic evidence by which their age might be determined. The section ceases with a heavy deposit of sandstone, No. 44, which, together with the subjacent strata, is apparently conformable with the whole rock series included in the section to the lowest Carboniferous limestones there shown. If non-conformity exists, it is so slight as to readily fail of recognition.

Looking south and southwest from Station XL, quite the entire area of the Low Pass basin is commanded, limited on the west by a rather high and rugged mountain ridge, which shows in its east face escarpments and amphitheatres recalling the magnificent scenery of the Téton western foreland. The intervening country is filled with low hills, and traversed by a net-work of narrow valleys and cañons, and clothed with coniferous forests. Here and there dull buff-colored exposures were observed in the hill-sides, but nothing affording familiar lithological characters sufficient for the determination of the relative age of the formations which they represent. But in the steep mountain wall which rises into the ridge immediately defining the eastern border of the lower valley of the Snake, a heavy series of drab deposits seem to indicate the Carboniferous. It may be that the before-mentioned basin-area of the Low Pass has been eroded out of the comparatively soft deposits of the Laramie Group, which may either occupy a broad synclinal depression or a series of narrow folds lying between the two main ridges which constitute the principal topographic feature of this mountain group.

The section B, of accompanying plate, gives a profile of these mountains, along a northeasterly and southwesterly line, passing through Station XL, which is based upon data secured by Mr. Bechler. The foregoing section, embracing the belt actually examined at this locality, is introduced to show its relation to the topography of the range along this line. The profile crosses the barrier ridge bounding the lower valley of the Snake a little to the north of the debouchure of the Low Pass drainage, to the north of which the ridge rises 1,500 feet higher than at the point where it is crossed by the profile. In the opposite direction the eastern border of the mountains is gained in a distance of only two or three miles beyond the northeast limit of the section, and from data

gained in the vicinity of Spring Creek, and at Station XLII, the Carboniferous limestones at this point are found to extend quite to the edge of Pierre's Basin, where they are buried beneath Post-Tertiary accumulations.

In the foot of the mountains, and in low outlying mounds a short distance south of Spring Creek, which issues a copious stream from a spring source in the limestone ridge, quite extensive exposures of drab, cherty limestone with crinoidal columns, overlaid by the reddish-buff siliceous beds, were seen, dipping to the southwestward at an angle of about 35°. These deposits doubtless belong to the lower portion of the series shown in the section through Station XL, given above. Between the latter locality, which we designated by the name Spring Point, and the debouchure of Low Pass Creek, the Jurassic beds occupy a belt which extends southeasterly over to the ridges southwest of Station XXXIX, in the Téton Pass Mountains. On the southwest border of this belt there are indications of a sharp fold in the Mesozoic strata which form the crest of the before-mentioned spur-ridge rising into Station XL, where, at one point, the heavy conglomerate ledge which overlies the drab Jurassic beds was observed to dip to the northeastward at angles of 30° to 50°. The latter exposure occurs in the crest of the spur-ridge but a short distance northwest of Low Pass Creek, and where the conglomerate is underlaid by chocolate red beds, which are in turn succeeded below by drab limestones, recalling the association of beds observed to the southwest of Station XL. But, higher in the ridge, its crest lies to the southwest of the axis of the fold, which also gradually rises in that direction, so that the southwest flank of the fold exhibits the strata reclining in that direction. It is possible the fold here alluded to may be of very local extent, which would readily explain the northerly expansion of the Carboniferous deposits appearing in Spring Point, and which are believed to belong to the ridge of Station XLII, as hereafter to be mentioned.

Soon after crossing Spring Creek, the foot-hills to the northwest show rusty weathered pinkish trachytic ledges, gently dipping toward the basin, or northeasterly—their first exhibition along this side of the basin after leaving the exposures in the debouchure of West Téton Pass Creek. On one of these upraised volcanic points Station XLI was established, at an elevation of about 2,000 feet above the lower level of the basin opposite. But to the southwest the sedimentaries are seen rising from beneath the volcanic border-deposits into a higher mountain ridge which forms an easterly spur prolongation of Station XLII ridge. The volcanics skirt the mountain foot for several miles to the northwestward, when they bear round to the westward, rising high up on the northern terminus of the range where they form the long foreland bench which descends over gentle grassy slopes into the great plain of the Snake.

Just within this fringe of volcanics, a rather extensive recess along the upper course of Packsaddle Creek is filled with low, rounded hills, rising into a more prominent ridge along the eastern border, and flanked on the southwest by the more rugged mountain ridge, on the culminating point of which Station XLII was located, at an altitude of 10,080 feet above the sea, or nearly 4,000 feet above the bed of Pierre's Basin. A section carried from the volcanic border along a southwest line into the heart of the mountains through Station XLII ridge is shown in the accompanying plate, section A, and exhibits the following stratigraphic elements:

Section through Station XLII.

1. Pink-colored trachyte, associated with dark basalt, dipping eastward at an angle of 15°. These deposits crown the elevation at Station XLI, and that to the northwest in the opposite side of the debouchure of a small stream which here penetrates the foot-hills.

2. Blue, rusty weathered, shaly sandstone, forming a narrow ledge exposure, which dips 35°, northeasterly. It is underlaid by gray, shaly sandstone *débris*.

3. Gray, brown weathered, shaly sandstone, dip 15°, southwestward; exposed in the foot of the opposite slope which rises into the prominent hog-back ridge overlooking the volcanic border-ridges.

4. Crossing a space of several hundred yards, in which no rock exposures appear, in the steeper northwest acclivity three ledges of gray, shaly sandstone outcrop, including a vertical thickness of 60 to 100 feet, and dipping southwesterly at an angle of 20° to 30°. From these ledges, which doubtless pertain to the same age as the previously-mentioned sandstones, we pass over the steep *débris*-covered slope to a point near the crest of the ridge, where the following bed appears:

5. Drab, fragmentary limestone, with segments of the column of *Pentacrinites*, showing a thickness of about 20 feet, in nearly vertical position, or dipping at an angle of 85°, southwesterly. This bed is separated from the succeeding by a narrow space, in which appear the following:

6. Drab, shaly limestone and indurated deposits, containing a small *Ostrea*, like *O. strigulecula* White, which, together with *Pentacrinites* remains, determine the Jurassic age of this horizon. The same and associated ledges are also seen in the steep ridge to the south.

7. Bluish-gray, shaly, fine-grained sandstone, exposed 5 to 10 feet in sharp hog-back crest of the ridge, dipping 85°, W. 15° S.

8. In the succeeding space of 200 yards or so, obscure exposures of pink-buff sandstone alone indicate the character of the several hundred feet of superimposed material.

9. Drab limestone, forming a heavy ledge, which dips steeply to the southwestward.

10. Very hard buff-gray and pink sandstone, containing obscure vegetable remains. This rock forms a heavy ledge, outcropping in the southwest slope of the ridge, which descends to the lower level of the intervening basin, in which the succeeding exposures are indifferently revealed, in part owing to their more friable nature, the materials derived from their easy disintegration effectually covering considerable areas of the undulating surface. Hence the following beds, which outcrop at intervals, probably show only the more indurated layers of a heavy series of deposits which fill the basin area above outlined. These are referred to under Nos. 11 to 13, inclusive, as follows:

11. Grayish and bluish-gray, thin-bedded sandstones, appearing in low obscure outcrops littering the surface with *débris*.

12. Gray, thin-bedded sandstone below, dark gray and buff-reddish, shaly, laminated sandstone above. In the belt apparently occupied by the above deposits, a heavy bed of drab indurated shales and dark brown-gray limestone layers occur, which afford fragments of a small *Ostrea* (*O. strigulecula ?*) and *Pentacrinites*, like those occurring in bed No. 5; the latter deposits were observed in the steep slope south side of the little stream which flows out into the basin immediately north of Station XLI, but their actual relationship to the gray sandstones was not satisfactorily disclosed.

13. Greenish gray soft sandstone, alternating with rusty red shales and brown-stained gray sandstone.

14. Gray and reddish-buff sandstone, interbedded with dark chocolate-colored and reddish indurated shales, with ferruginous nodules and drab, chocolate-stained limestone layers. The lower exposed portion of the deposit consists of a hard, laminated, reddish-gray sandstone associated with a dark brownish red conglomerate, dipping 55°, W.

15. Drab limestone, in heavy and thin-bedded layers, dipping 45° to 55°, S. 50° to 70° W. This limestone forms a heavy deposit, resting upon the last described sandstone, appearing in the summit of the east spur of Station XLII ridge and heavily flagging the slope descending to the saddle which connects the spur with the above mountain ridge. Certain layers of the limestone contain numerous individuals of a small undetermined Gasteropod, which was the only fossil observed.

16. Brown, gray, and pink sandstone, with joint structure; forms a heavy bed in the east side of the saddle, dipping towards the mountain, or W. 10° S., at an angle of 47°.

17. Variegated blue and chocolate-colored arenaceous shales, occupying the depression in the saddle, one and a half miles east of Station XLII.

18. Heavy-bedded drab limestone. In climbing from the above-mentioned saddle to the west of the southeast continuation of Station XLII ridge, the above limestone appears in heavy ledges mailing the steep northeast face of the mountain, where the ledges appear to incline to the eastward at an angle of 65°. Higher in the slope at this point the surface is strewn with the fine angular *débris* of reddish-gray very hard siliceous deposits, or brittle quartzitic sandstone, apparently forming a heavy ledge, the relation of which to the limestone was not satisfactorily shown. But in passing up the ridge towards its culminating point, the crest of the mountain was found to be capped by a heavy deposit of darkish and light-drab, spar-seamed, cherty limestone, sometimes brecciated, which afforded a few characteristic Carboniferous corals (*Zaphrentis* and *Lithostrotion*), overlaid by alternations of heavy buff-pink siliceous beds and thinner limestone layers, all dipping S. 30° W. at angles of 35° to 45°. The latter beds are indicated in the section-diagram under Nos. 19 and 20.

The main ridge which culminates in Station XLII, thus forms a monoclinal crest extending three or more miles in a general northwest and southeast direction. Under the summit the northeast face presents exceedingly steep slopes descending into amphitheatres, whose beds are choked with *débris* accumulations and furrowed by the drainage ravines which descend into the basin area. In this northeast wall a thickness of 400 feet or more of the Carboniferous limestone is exposed before the slope merges into the steep talus at its foot, which effectually conceals the inferior deposits. On the opposite hand, the ridge more gently slopes into a parallel depression, over the before-mentioned siliceous deposits, which latter, doubtless, are as fully developed at this locality as they were found in the ridges north of Station XL. In the opposite acclivity the "red beds" appear in equal force, broad patches of the brilliant color contrasting with the rich green herbaceous growth which here as elsewhere flourishes in the soil based upon these deposits. The latter are succeeded by the drab beds of the Jurassic, which rise up into the crest of a higher mountain a couple of miles south of Station XLII, where they are capped by a heavy rusty ledge which may be traced several miles to the northwest descending into the deep valley at

the head of Cañon Creek, in the further side of which it is continued until lost to view in the forest-covered slopes. The latter ledge may be identical with the conglomerate shown in the section through Station XL, of which, indeed, the present mountain ridge is the northwesterly prolongation. To the southwest lies an equal breadth of hill country intervening between the crest of the range and the lower valley of the Snake, the exploration of which was, for the lack of time, prevented.

Station XLII commands a view of the entire extent of the little basin to the north and east, and which is principally drained by the sources of Packsaddle Creek. Its undulating surface shows obscure exposures of the peculiar gray sandstones enumerated in the foregoing section, which apparently compose the bulk of the strata out of which the basin has been excavated. The ridge along its eastern border, in which the hog-back ledges of Jurassic limestone and sandstone appear, is broken down to the northeast in the wide debouchure of the principal drainage channel into Pierre's Basin, to the north of which the hills gradually rise into the high volcanic bench which reaches high up on and sweeps around the northern terminus of the range. From the nature of the basin deposits, which readily yield to the denuding agencies which have molded the surface into its present configuration, it is difficult to gain a clear knowledge of their stratigraphy, only the firmer ledges protruding above the surface in such favored localities where they have escaped being buried beneath the detrital material derived from the demolition of the softer beds. But in their lithological appearance they share so marked resemblance with horizons in the Caribou Range west of the lower valley of the Snake as to almost preclude a vestige of doubt as to their identity with the extensively-developed Laramie deposits of the latter region. The east hog-back ridge to the south is blended with the eastern spur of Station XLII ridge, on the volcanic tipped foot of which Station XLI was located. In the latter spur the steeply-inclined Jurassic strata are continued southeasterly, finally running out in the border of Pierre's Basin, where they have been eroded and covered with modern accumulations. The relations of the folds and disturbances here met with, with similar manifestations occurring in other parts of the range to the southeast, will be briefly discussed at the close of this chapter.

TÉTON PASS MOUNTAINS.

Without attempting here to define the limits of the so-called Téton Pass Mountains, for our present purpose it answers merely to state that that portion of the mountain region south of the Low Pass which fell under our examination comprises a narrow strip skirting the head or southern end of Pierre's Basin, extending thence southeasterly to the foot of Jackson's Basin on the Upper Snake. The southern end of the Téton Range is terminated in a pair of lofty peaks which overlook almost the entire extent of the mountainous highlands which fill the great southern bend of the Snake River south of the Low Pass Gap, and which is dominated by Mount Baird. Along the western border of the mountains the rugged barrier here and there rises into comparatively prominent peaks, conspicuous among which are Promontory Peak, and the corresponding height to the north, which together form the portal through which the drainage of the Low Pass Basin makes its exit into the lower valley of the Snake. This low mountain ridge is separated from the Téton Range by the depression through which lies the Téton Pass, the summit of which attains an elevation of some 2,300 feet above the basin-plains at either entrance to the pass, or an actual altitude of

8,530 feet. The immediately neighboring ridges attain altitudes less than a thousand feet higher, sinking away in opposite directions to the northwest and southeast, where they are crowned with innumerable peaks 7,000 to 9,000 feet elevation above the sea. This region is very generally clothed with coniferous forests; the northern slopes especially are often densely wooded with beautiful growths of slender-tipped spruce and pine, the presence of which offered serious obstacles in the way of tracing out the geological structure in distant parts of the range beyond our reach.

The Téton Pass hills, as seen from the plain in passing along the southwest border of Pierre's Basin, present a succession of ridges gradually diminishing in height as they approach the Low Pass sag, their northerly face falling abruptly over the edges of the upraised strata, which in like manner determine the gentler slope of their opposite declivities. In connection with the Pierre Mountains, mention was made of the occurrence of a heavy ledge of conglomerate overlying the drab shaly horizon of the Jurassic, the relative position of which is further shown in the section B, bed No. 37. The strike of the strata maintains this ledge in the crest of the southeast continuation of Station XL ridge, where it is lost in the debouchure of Low Pass Creek; but to the southeast it reappears in one of the low ridges above referred to, where it is observed dipping southwestward, overlaid by drab limestone and hard sandstone, offering the same succession of deposits which compose the uppermost series in the section through Station XL in the Pierre's Mountains. These deposits rise in the crests of the ridges to the southeast, in which direction the strike of the strata carry them farther and farther into the mountains, so that, as we approach Téton Pass, the foothill ridges reveal successively older deposits, until, at the head of the basin, the upper measures of the Carboniferous appear in the foot of the spur which afforded access to Station XXXIX—a low mountain summit commanding a comprehensive view of the beautiful plain of Pierre's Basin, bordered on the one hand by the great foreland slopes of the Téton Range, and on the other by the comparatively low but more broken foot-hills of the Pierre's and Téton Pass Mountains.

The vicinity of Station XXXIX afforded instructive geological study, showing the intimate relations in the stratigraphy and dynamics which exist in common between this mountain group and that briefly noticed in the preceding pages. The summit of the mountain is capped by a heavy ledge of rather hard, even-bedded, pale brick-red sandstone, dipping 46°, W. 10° S. The rock is complicated by joint structure which might easily be mistaken for the bedding but for the lamination, obscure traces of which the rock sometimes retains. The deceptive joint or cleavage planes incline north at an angle of 40°. The only vestiges of organic remains contained in the rock are small algæ-like markings preserved in a variety of curious shapes weathered in relief on the exposed surfaces of the slabs. The rock is also perforated by slender tubes and cavities which may have connection with original organic nuclei. To the southeastward, just beyond an intervening, deep, densely wooded gulch, the same ledge is traced in the crest of a corresponding ridge, the south slope of which is covered with the rusty *débris*. On the south slope of Station XXXIX a considerable deposit of dark drab, spar-seamed, fragmentary limestone, with associated shaly beds, occurs, which doubtless overlies the above-mentioned sandstone; it contains a few poorly preserved fossils, small crinoidal discs, the flat valve of an *Aviculopecten?* a small lamellibranch resembling *Myacites*, and a little gibbous gasteropod. Although none of these forms are positively identifiable with

known species, they show strong resemblance to forms which occur elsewhere in well-determined Jurassic horizons. In the wooded slopes to the south and southwest of the station, belts of variegated pale red and drab deposits are exposed in the secondary spurs descending from the main ridges, the strata dipping off to the southeastward as far as could be traced. The north spur descending to the plain exhibits successively lower deposits, which, although it was impossible to ascertain their thickness even approximately, occur in the following order: Immediately beneath the summit sandstone the north and northeast slope of the station passes over a heavy deposit of deep red arenaceous shales and thin layers of red sandstone which descend into the saddle connecting this point with a lower nipple; the edges of these red beds and overlying sandstone are also exposed in the northeast slopes of the next west spur. In the crest of the nipple north of the station, shaly buff-gray sandstone, overlaid by gray limestone, is seen, and thence to the northward successive ledges of very hard reddish buff siliceous or sandstone beds appear, interbedded with drab and dark gray limestones and red arenaceous indurated shales, dipping southwesterly at an angle of 20° to 30°, the hard ledges forming low crests along the gradually declining spur. Near the foot of the ridge, and perhaps two and a half miles north of the station, a heavy ledge of darkish drab cherty limestone appears, rising obliquely to the general direction of the spur, and dipping W. 5° S. at an angle of 20°. This ledge afforded a few specimens of *Zaphrentis* and crinoidal remains, identifying it with the Carboniferous. It will hence appear that the overlying siliceous beds, sandstones, and interbedded red shales and limestones offer the same stratigraphic series as that noticed in the Pierre's Mountains, north of Station XL and south of Station XLII.

It remains briefly to notice a remarkable but, unfortunately, obscure exposure occurring in the southeasterly slope of Station XXXIX. This shows a limited exposure apparently belonging to a heavy ledge of gray limestone which stands nearly vertical, the top of the ledge bending suddenly over to the southward, and otherwise showing what appears to be the result of great disturbance. The apparent planes of bedding show a strike E. 25° to 30° S. and W. 25° to 30° N., the planes steeply dipping northward or nearly vertical. In the absence of other exposures in the immediate vicinity affording the least corroborative evidence of the existence of so sharp a fold in the strata at this point, renewed search was made to discover whether or no the apparent bedding of the limestone was to be attributable to deceptive cleavage, as remarked in connection with the sandstone ledge in the near summit of the station, with which the strike of the limestone certainly shows marked coincidence, but without more definite results. It is by no means of infrequent observation in this region to find the heavier limestone deposits of both the Carboniferous and Jurassic so changed and fractured by cleavage as to totally obscure the true bedding of the ledges, which in many instances is only determinable by noting the relation to associated strata which clearly retain the original planes of deposition. But examining the country to the eastward of Station XXXIX, in the belt of low hills intervening between this point and Téton Pass there occur in the crests of one or two spur-ridges the edges of southwest-facing ledges which apparently dip in the opposite direction, indicating a fold the axis of which cannot be far removed from the ridge of which Station XXXIX forms one of the western culminating points.

The occurrence of the "red beds" and Jurassic limestone in the lower portion of the valley of West Téton Pass Creek has already been alluded

to in connection with the notice of the southern extremity of the Téton Range. These deposits doubtless here recline on the flank of the great range, dipping southerly conformably with the Carboniferous deposits which rise up into the high dominating peaks at this end of the range. As there mentioned, the volcanics fringe the foot-hills well up into the little valley, on the southwest side of which, however, they were not recognized. It was a notable fact that the foot-hills of the Séton Pass and Pierre's Mountains below Station XXXIX were quite denuded of the latter class of rocks, which on that side of Pierre's Basin do not reappear until we have passed to the north of Spring Point, where they again exhibit characteristic upraised benches resting on the border foot-hills. Passing up Téton Pass the way gradually penetrates alike deeper into the range and lower in the geologic series, so that, at a point two to four miles from the summit of the pass the Carboniferous ledges heavily plate the immediate mountain slope. There the diminished brook again turns southeast and soon passes into the horizon of the "red beds," which continue to the high saddle next west of the summit, where they display characteristic exposures of deep red sandstone and arenaceous softer beds, dipping southward at an angle of 45°. From the latter point the trail again passes north of the trend of the "red beds," the way passing over steep slopes buried beneath vast accumulations of intensely hard, fragmentary, buff, and reddish silicious rock, which was found to be heavily developed and composing a zone of low elevations immediately south of the summit. The relative position of the latter silicious horizon is well discerned from the mountain which rises immediately north of the pass, Station XLIII.

From the latter mountain summit the view embraces the whole country, sweeping round from the east, south, into the west, and commanding nearly the whole of the highland region crowded into the great southern bend of the Snake River. In the immediate neighborhood of the Téton Pass the silicious deposits of the upper measures of the Carboniferous form a belt of low hills, in whose steep declivities bands of the included red, gritty shales simulate the "red beds" of the Trias, only much less considerable in vertical extent. But just beyond, in the slopes descending from higher ridges, appear here and there extensive open tracts whose cover of luxuriant herbage we had come to associate with the presence of peculiar geological deposits; and we have the confirmation of the supposition in numerous slides in the steeper slopes, which reveal extensive exposures of the Triassic "red beds." These deposits are easily traced in a wide belt having a general west-northwest and east-southeast trend, in the former direction passing down into the lower course of West Téton Pass Valley, and in the latter extending into the foot-hills south of East Pass Creek, where they are hidden from sight by the forests which very generally cover the hills in that quarter. Still beyond, southwest, the ridges show quite extensive exposures of buff and grayish deposits, to the southwest of which another belt of "red beds" intervenes between the last and the immense accumulation of light-drab strata dimly seen in the escarpments of the prominent mountain heights which rise immediately from the eastern border of the lower valley of the Snake. This is, in brief, what appears from the commanding summits north of the pass. The distance is too great, to say nothing of the great extent of surface clothed in forests and other growths in which the subjacent strata are concealed from view to render it possible to gain more than the barest general outlines of the distribution of the geological formations, not even the inclination of the strata being satisfactorily revealed in the middle and more distant ridges; while, of course, all stratigraphic

details are effectually obliterated. Hence, it is with a degree of hesitancy that the belt of buff-colored deposits is identified with the Laramie formation, and the more distant red-colored strata with the Triassic "red beds," or the variegated red shales overlying the former deposits. But the drab beds in Promontory Peak and corresponding heights along the lower valley of Snake River may with greater confidence be referred to the Carboniferous, the latter deposits having been observed in that quarter by Professor Bradley in 1872.

A brief review of the facts and their bearings elicited by the examinations in the northern portion of the range, will, it is hoped, convey something like an adequate knowledge of the identity of the geologic history of at least the northeastern if not the whole of this mountain region.

In the extreme northeast, a limited area of Jurassic and, perhaps, Laramie deposits occupies the northeast flank of the Pierre's Mountains, where the strata have been involved in extraordinary disturbances, which have indeed tilted the Jurassic beds into nearly vertical position in the immediate vicinity of the present eastern border of the range, and it seems probable that a complete overturn of the beds at this point was effected. The narrow belt of extreme disturbance soon passes beyond the limits of the range to the southeastward, where, in Spring Point, the Carboniferous deposits jut out into the edge of the basin. The western border of the disturbed Mesozoic area, as we have already seen, is defined by the high barrier ridge of Carboniferous strata, which may in places retain the condition of a fold with steep easterly pitch, but which at other points seem to have been faulted with downthrow in the same direction.

At Station XLII the erosive agencies have reduced this ridge to the condition of a monoclinal, but in the immediate vicinity evidence exists which strongly goes to show that the uplift began either as an anticlinal fold, or in the severance of the strata, the edges of the upraised portion dragged, producing the appearances above referred to in comparing the ridge to a faulted anticlinal fold. The downthrow of the fault has brought the Jurassic or Post-Jurassic beds down to the level of the Carboniferous limestones, against which they apparently impinge, dipping in the same direction as the monoclinal portion of the latter deposits, though at a steeper angle, southwesterly. The appearances here allnded to are indicated in the section through Station XLII. With the time at our disposal it was difficult to work out the details of the disturbance the Mesozoic deposits have undergone in this northeastern area. The two dominant ridges, as determined by the fossil contents of their respective limestones, are apparently made up of stratigraphically widely separated deposits. The considerable space intervening and representing a vertical extent of probably near 8,000 feet, is filled with arenaceous deposits which certainly bear strong resemblance to Post-Jurassic or Laramie deposits, and so also in regard to the soft sandstones in the outlying flank, where they appear to form a low fold, on the one hand inclining northeastward and on the other dipping in the direction of the sharp outer ridge, whose crest is composed of steeply tilted Jurassic beds. From such evidence it seems perfectly natural to attribute the appearances here met with to violent disturbances which resulted in one or more sharp folds, and perhaps accompanied by faulting, of which the area of their exhibition as seen to-day is but a remnant of a wide and much involved belt in the region now occupied by the plain of Pierre's Basin.

The faulted or monoclinal ridge of Station XLII pursues a course

southeasterly, but much wasted by the erosion of the upper tributaries of Horse Creek, and finally reaches the edge of the basin in Spring Point. This southeastern portion of the ridge apparently occupies a relatively much broader area than do the same deposits in the vicinity of Station XLII. This may possibly be due to one of two causes, or both, namely, variation in the trend of the strata, or a series of minor undulations and fractures superadded to the primary fold, by which the same horizons are made to appear at corresponding levels over a considable surface transverse to the trend of the main uplift.

South of Spring Point the Jurassic deposits are seen in the foot-hills or spurs all along the edge of the basin to a point beyond Low Pass Creek, where they, together with the "red beds," gradually pass inland, so that the Carboniferous ledges again appear from beneath the Mesozoics, lapping up on the lower spur-ridges in the vicinity of Station XXXIX. The latter belt of Carboniferous doubtless belongs to the Station XLII uplift, the axis of which probably lies a little east of Station XXXIX, in which quarter, as previously remarked, there are indications of a synclinal depression occupying the narrow belt intervening between the latter point and the southwest base of the Téton Range, in the farther side of which West Téton Pass Creek has excavated its valley. There is one other feature observed in the immediate vicinity of Station XXXIX in the apparent sharp folding of the strata with abrupt northerly pitch, which offers additional striking resemblance to the conditions observed in Station XLII ridge, and together with the corresponding trend of the strata, it seems hardly possible to doubt the identity of the uplift at these distant points, and its extension southeastward to the border of the valley of the Upper Snake.

Of the large area to the south we possess far too meager information to warrant more than reference to the salient features of its apparent geological structure. From the observations of Professor Bradley, who, in 1872, traversed the Grand Cañon of the Snake, and thus had opportunity to study the strata appearing along this magnificent natural section, it appears that the greater portion of the cañon is walled by Carboniferous deposits. These deposits are described by Professor Bradley as being mainly composed above of a thickness of several hundred feet of limestones, gradually passing from massive into overlying shaly beds, the lower deposits consisting of sandstones and shales, including heavy beds of limestone, which together reach a thickness of 2,000 feet or more. The upper entrance to the cañon shows a heavy series of laminated red sandstones, from beneath which appears a thickness of several hundred feet of heavy-bedded and shaly gray and greenish sandstones, interbedded with calcareous shales, and containing indeterminate vegetable remains. The latter deposits extend into the cañon some distance beyond the mouth of Hoback's River, where they are thrown up in a sharp anticlinal fold with steep inclination, 65° to 70°, about east-northeast, dipping at an angle of about 40° in the opposite side of the fold. The axis of this uplift shows a narrow fold of limestone, overlaid by a heavy mass of sandstones and cherty beds, including near the base two or three heavy beds of black calcareous shale and friable clay, containing what appear to be amphibian remains. To the northeast, between the latter fold and the upper entrance to the Grand Cañon, the above-mentioned sandstones are thrown into two parallel but much lower anticlinals, having the same general trend, or west of north and east of south, with steeper dips on the east. Below the great fold above mentioned, in descending the cañon, Professor Bradley refers to three other sharp anticlinals which are closely crowded, and showing exceedingly steep dips, in some instances amounting to 85°, accompanied by

other manifestations apparently of more or less local character, as the change in the strike from the general northwest and southeast direction to courses east-west and north-south. Beyond this point the Carboniferous deposits are boldly upraised, and thence to the debouchure of the cañon, a distance of some ten miles, they constitute the mass of the cañon-walls.

The above recapitulation of the Grand Cañon section has been introduced to facilitate the comparison of the interesting region it traverses with the region visited along the northeastern flank of the same range of mountains. It will be observed that Professor Bradley notices a heavy series of sandstones and siliceous deposits making up the lower half and more of the Carboniferous series in this quarter, where the upper deposits are almost entirely composed of limestones. This shows a striking change in the character of the earlier sediments of the Carboniferous period in this quarter, especially as compared with what obtains in the Téton Range, where the lower beds are mainly calcareous. It is possible that the section in the Grand Cañon does not retain the uppermost deposits, which, as we have already seen in the region of the Pierre's Mountains, are usually made up of alternations of heavy beds of hard sandstone and limestone layers. The great breadth over which the Carboniferous beds outcrop in the Grand Cañon also offers something strongly in contrast with their apparent limited occurrence in the barrier ridge along the lower valley of the Snake in the northwest continuation of the same range. But this state of things may meet with satisfactory explanation in the fact that, in the process of excavation of the lower valley, a vast mass of their strata has been removed, the valley gradually widening and encroaching more and more on the Carboniferous belt in its progress to the northwest, in which latter quarter it has left a narrow remnant-strip on the southwest side of the valley, while above the entire area of the belt is confined to the Snake River Range where, in the vicinity of the Grand Cañon, it maintains its original breadth. The Carboniferous axis in the eastern flank of this range is not recognizable in the cañon section, which, if it extended so far to the southeast, probably gained the upper valley of the Snake above the Grand Cañon. It is much more difficult to correlate the red sandstones and the gray and green sandstones which compose the rocks for the first few miles on entering the cañon from above. Professor Bradley's description of the lower gray and green sandstones and calcareous shales answers well the appearance of a heavy series of strata which occupies the little basin area at the northeast extremity of the Pierre's Mountains, where very similar beds are associated with Jurassic deposits, but so inextricably confused as to involve their relations to the latter formation in much obscurity. But, on lithologic grounds, the deposits at the latter locality were compared with the Laramie beds, and it may further be observed that the latter formation, as here defined, also holds extensive deposits of red sandstones, and it is possible that the beds noticed by Professor Bradley belong to this early Cenozoic group. In the event of the confirmation of the latter supposition, may not these exposures in the upper portion of the Grand Cañon belong to the series of gray and buff and red strata which appears in the broad belt stretching across this highland region between the southeast flank of the Stations XXXIX and XLII uplift and the great Carboniferous barrier ridge along the lower valley of the Snake?

PIERRE'S BASIN.

The bay-like recess known as Pierre's Hole or Basin occupies the interval between Téton Range and the Snake River Mountains, and com-

municates directly to the north with the great plain of the Snake River Basin. It has a north-south extent of about 18 miles, and at its widest part, opposite the north end of the Snake River Mountains, an east-west breadth of about 11 miles. To the south it very gradually narrows into the rounded upper end of the basin, while to the north it is defined by a relatively low, inconspicuous upland barrier which gives to the included area a general oval outline, embracing an area of, approximately, 140 square miles, with a mean elevation of 6,000 feet above the sea. Pierre's River traverses the basin nearly centrally, its principal source rising high up in the Téton plateau, and is joined near the head of the basin by West Pass Creek, which latter affords a natural highway communicating with Jackson's Basin on the Upper Snake. The principal tributaries from the east all originate in the Alpine basins in the heart of the great range; they are the Fox, Goodfellow's, West Téton River, Bear and Leigh's Creeks, besides several other smaller streams which collect the surface drainage of the western foreland. Numerous spring-fed creeks and rivulets join the main stream on its left bank after a short course from the low mountain border which defines the west side of the basin.

The basin-plain has a descent of 400 to 500 feet from its head at the debouchure of West Téton Pass Creek to the point where the main stream begins its cañon course across the volcanic-capped low upland barrier which extends across the north end of the basin below Leigh's Creek. A wide strip of level alluvial land lies immediately adjacent the stream, the damming of which by beavers has converted the larger portion of the intervale into a swampy tract, covered with luxuriant meadows, dense copses of willow and ponds, through which the channel can with difficulty be traced. On either hand the plain gently rises in broad stretches of terrace slopes, which abut against the low volcanic border of the western foreland of the Téton Mountains, and also north of Spring Point in the opposite border; but south of the latter locality these benches rest upon the sedimentary beds which here form the mountain foot. Within the basin area, the larger streams have built up quite extensive detrital deposits in the form of broad tongues extending out into the basin from their debouchures, the channel following their crest, from which the surface very perceptibly slopes in either direction into shallow troughs which in some instances are occupied by the small drainage channels that rise in the foreland.

The above features are quite marked in the case of West Téton River and Goodfellow's Creek, the foreland Rapid Creek flowing out into the intervening depression; and, as seen from the opposite heights in the Pierre's Mountains, Bear Creek and Leigh's Creek are also seen to emerge upon similiar raised tongues. But in the west-side streams this peculiar feature is not well, if at all, developed, the streams having cut their channels through the gentle terrace slope which is here more uniform in its surface contour, or has been less modified by the addition of detrital materials brought down by the streams and superimposed on the more ancient terrace formations. For there can be no question as to the comparative modern origin of the raised tongues alluded to, and which manifestly owe their formation to the local action of the streams. This is further clearly shown in the fact that the shorter and less powerful water-courses have failed to make the same impression on the local topography of the basin area, their volume being inadequate for the transportation and distribution of so extensive quantities of detritus. The later action of the streams has eroded their beds to a depth of 10 to 30 feet or more in the loose materials, from which at various stages in

their volume they have fashioned typical terraces, which reach up the larger valleys a greater or less distance, as noted in West Téton Valley, Good Fellow's, Fox, and West Pass Creeks. These terraces, in every respect typical examples of their kind, show different levels, 5 to 25 and 40 feet above the level of the streams, the lower, and of course most recent ones often strewn with coarse materials which enter into the composition of the deposits out of which they were moulded. Along the south and west sides of the basin the surface slopes down in a broad gentle terrace to the lower level of the plain, in which the streams at their debouchures have deepened their beds. These terraces seldom show marked or abrupt borders along their lower edges, but instead they generally merge into the lower level tract with but slight demarkation, and this generally to be sought rather in the gravelly character of the soil, which usually marks the edge of the terrace-border.

The components of the general terrace formation that fills the basin chiefly consists of abraded rock fragments, gravel, pebbles, and small bowlders, intermingled with finer sediments, and very generally covered with a mantle of fine light-drab or brown soil. However, frequent and more or less extensive tracts are covered with gravel, like bars, where the coating of finer soil has been washed away. In the lower portion of the basin, the low banks along Pierre's River reveal quite extensive exposures of light earth, which recalls the modern or lake beds of Dr. Hayden, noticed elsewhere in this region, underlying or incorporated with the later volcanic flows. Their occurrence here, in the near proximity to the basaltic flows, strongly suggests the ascribed relationship. It may be impossible to determine the vertical extent of these earlier Quaternary deposits; but that they may reach a thickness of several hundred feet in the middle of the basin depression and elsewhere, locally, seems not improbable.

Although, for all that can be said at this time, the superficial deposits occurring in the basin may not be treated strictly in accordance with their chronological sequence, but, from the similarity of their components, the fluviatile deposits may here receive brief notice. The position of these deposits in the debouchures of the streams descending from the mountains has already been referred to, as, also, their peculiar conformation. It is rarely, so far as our observations went, that the mouths of the debouching streams are filled with accumulations that strongly suggest morainal origin. The barrier in the mouth of West Téton Valley and the ridges on the north and south may prove to be the remains of the terminal and lateral morains of a glacier that once filled that valley. But elsewhere, so far as observed, these deposits have been remodeled to such a degree as to be clearly ascribed to the work of the streams themselves. Their sources and the progress they have made in the process of deepening their beds are all plainly recorded in the character of the deposits which they have built up along the border of the basin. The short foreland streams south of West Téton River are paved with more or less rounded fragments of sandstone and volcanic rock, such as occur *in situ* in the great foreland in this quarter; while the larger streams have swept down immense quantities of thoroughly rounded fragments of all the sedimentary rocks which their courses traverse, and which, in Bear Creek, West Téton, and Goodfellow's Creek, are intermingled with a large proportion of metamorphic bowlders which were torn from ledges deep within the range. West Pass Creek, and all the streams along the west side of the basin, are strewn with sandstone and limestone bowlders only, save occasional fragments of volcanic rocks; the absence of granitic rocks

indicating that the mountain courses of the streams lie entirely in the sedimentary formations, which is further proved to be the fact by actual observation. In the northern part of the basin, Leigh's Creek, the sources of which originate in the great Archæan expansion in the northern half of the Téton Range, and flow out through the volcanic foreland which here flanks the metamorphic nucleus, shows in its bed quantities of gneissic, schistose, and volcanic bowlders, and which compose the low bars and bordering terraces.

In defining the limits of the basin area, mention was made of the low upland barrier across its northern end. It remains to notice the geological character of this barrier, which presents the appearance of a low, gently undulating prairie upland, on the one hand gently descending from the well-defined foot of the Téton Range, and on the other from the northern terminus of Pierre's Mountains, uniting below Leigh's Creek, where it is broken through at its lowest part by Pierre's River, which here begins its cañon in the volcanic rocks. This upland really belongs to an extensive tract, extending northward to Henry's Fork of Snake River, and in which a large part of the courses of Pierre's River and the North Fork and several smaller tributaries lie in narrow cañons, 100 to 500 feet in depth. The general slope is quite gradual, northwestward; on the divide just south of Cañon Creek, where it probably attains its maximum height, about 6,600 feet, to the bluffs on Fall River, a few miles above its confluence with Henry's Fork, the descent being in the neighborhood of 1,400 feet.

The entire tract is based upon the older volcanic flows, which show in the deeper cañons several hundred feet thickness of laminated porphyritic trachytes, overlaid by drab and pink trachytes or trachytic tuffs, upon which rest in turn remnants of firmer dark-brown, somewhat vesicular lava, with probably other varieties of trachyte and trachytic lavas, extending to the lower level of the Snake Basin, where they are replaced by the ordinary basaltic flows which everywhere floor the great plain. To the first mentioned varieties belongs the volcanic fringe which rises up on the western foot of the Téton Range throughout its length between North Fork and West Pass Creek, and which reappears along the foot of Pierre's Mountains, at a point about due west of the mouth of West Téton River, to the south of which they have been denuded. From either side of the basin these deposits converge in gradually diminishing benches toward the head of Pierre's Cañon, presenting an abrupt breast on the basin side and gently inclining with the inclination of the flows in the opposite direction, or northward. There is apparently a series of two or more of these benches, which formed as many barrier levels across the northern end of Pierre's Basin, the gradual drainage of which explains the shelving contour of the older terrace formations with which it is filled, and which probably date subsequent to the volcanic eruptions. The surface of this upland barrier is generally composed of a finely comminuted light-brown soil, covered with a luxuriant growth of grasses and herbaceous plants. Wherever the wash has bared the steeper slopes, there appear exposures of water-worn drift materials. These loose materials were doubtless spread over the surface of the subjacent volcanic deposits prior to their erosion and removal from the basin area. So it would seem that, within comparatively modern date, the whole Snake River region was submerged, while the sluice-like accumulations filling the debouchures of the basin streams, and which form to-day a by no means inconspicuous feature in its surface relief, are absolutely modern, belonging to a past not very remote even to human comprehension.

CHAPTER IV.

THE EASTERN SECTION.

GENERAL TOPOGRAPHICAL FEATURES, DRAINAGE, ETC.

So far as relates to the somewhat partial nature of the geological examinations in the region to the east of the Téton Range, it may be made to embrace a belt of territory nearly coextensive, north-south, with the extent of Jackson's Basin along its western border, or about 40 miles; a line carried east from Jackson's Lake, along the divide between Buffalo Fork and the sources of the main Snake River, to the continental watershed, defining its northern limits. To the south and east of the above boundaries, in the interior portion of the area, our examinations were merely such as it was possible to make from commanding mountain summits, by which means, in perhaps the majority of cases, it was possible to gain, at least, a general knowledge of a much wider extent of country than that actually visited.

By far the larger portion of this area belongs to the drainage of the Columbia, and, hydrographically, it is further divided into three well-defined subsections, viz, the southern, including the area north of Hoback's River and south of the Gros Ventre River; the middle, or that between the Gros Ventre and Buffalo Fork; and the northern, a belt of country embraced between the latter stream and the extreme eastern sources of the Snake. The Buffalo Fork and Gros Ventre, both beautiful, well-sized mountain streams, rise in the continental divide, and flowing westward join the Snake in its passage through Jackson's Hole. The Gros Ventre drains the larger area, but Buffalo Fork is, perhaps, scarcely inferior in the volume of its waters. In respect to Hoback's River and the country along the southern flank of the Gros Ventre Mountains, which it in part drains and which in part belongs to the Green River drainage, our information is as yet wholly based on such accounts as have reached us from the hunters and explorers, who have casually visited or passed through that region with other objects in view than its careful exploration.

In surface reliefs the three above-mentioned subsections differ greatly one from the other; and this difference, as we shall see presently, is due to the geological features characteristic of the several quarters, and which will be taken up in connection with the description of these areas. In the northeast, a narrow belt east of the continental watershed, on the headwaters of Wind River, was visited in the course of the season, where we had opportunity to extend our general examinations southward as far as Union or Warm Water Pass, and thence along the northeast foot of the Wind River Mountains. This opportunity, notwithstanding the limited time a hasty passage through the country afforded, enabled the acquisition of many interesting details and a general knowledge of the geological relations of the orographic features of this part of the great watershed, and which find so diverse expression in the grandeur and unity of the great displacement out of whose metamorphic axis were fashioned the chain of snowy peaks and labyrinth of am-

phitheatres and profound gorges that mark the crest of the Wind River Mountains, and the scarcely less remarkable or inferior volcanic heights in the vicinity of To-gwo-tee Pass and the region around the sources of the Yellowstone.

JACKSON'S BASIN.

Before passing to the consideration of the highlands of this portion of the district, which will be treated of in specific connected order, a brief notice of the mountain-locked valley commonly known as Jackson's Hole, will first engage our attention. Extending in a northerly and southerly direction a distance of about 45 miles, ranging in breadth from 5 to 15 miles, and in altitude 6,000 to 6,800 feet above sea-level, it presents a surface diversified by levels of low, gravelly bottom, beautiful terrace-plains, with low, grassy hills rising in the midst, and densely timbered ridges skirting the western border, along which are nestled the lakelet expansions of the streams that issue from the Téton Mountains, and to the north the beautiful body of water into which the Snake River expands, which has received the name of Jackson's Lake. To the west rises the lofty, precipitous barrier of the Téton Range, which to the north sinks to the level of the high outlying volcanic divide at the northern extremity of the range, and to the south is prolonged in the mazes of the Snake River Range, forming a continuous belt of rugged mountain wall abruptly hemming this side of the valley. On the east the mountain border is much less regular and elevated, with a wide belt of outlying, gentle slopes, interspersed with forests of pine, groves of aspen, and extensive tracts of pasturage. Perhaps no region in the Northwest presents so varied, beautiful, and majestic scenery.

Quaternary.—The whole valley is filled with an immense accumulation of Quaternary deposits, consisting of well-water-worn or rounded *débris* derived from the neighboring mountains, and which the action of the streams has formed into various terrace-levels, the higher of which form quite extensive plains covered with sage and excellent grazing. The soil is of a light-brown marly nature, based upon a subsoil of coarser materials; which latter often appears at the surface in the lower bottoms, and also in the higher levels, giving rise to gravelly, barren tracts. Again, considerable areas of the bottoms along the beaver-dammed water-courses are converted into ponds and willowy bogs, which merge into luxuriant, spongy meadows, very like the natural vegas of the Southwest. The streams are generally rapid and shallow, their clear, cold waters spreading over bowlder-strewn beds and interrupted by bars of shingle and cobblestones, which often divide the streams into a network of easily-forded channels; but in the season when their volume is swollen by the melting of the snow and their banks run full, they present far more formidable obstacles to the progress of the traveller.

In the debouchure of East Pass Creek the west-side terraces may be well studied. They are seen to form high undulating and sloping benches, for the most part heavily timbered with impenetrable tracts of young pines, and strewn with large blocks of granite. In their passage across this bench the small streams have eroded pretty little valleys 40 to 60 feet deep, and have also built lesser terraces, which are conspicuous for the prevalence of water-worn fragments of sedimentary rocks, sandstone and limestone, which the streams brought down at a later period. To the north, however, it is very likely that Archæan *debris* prevails throughout, in the ancient as well as in the more recent formed benches. Professor Bradley and Mr. Taggart, who examined in this quarter the outlying benches immediately at the foot of the culminating Archæan

peaks of the range, found evidence that persuaded them of the glacial origin of the low parallel *débris*-ridges which there skirt the foot of the mountains. To the south the evidence is far less convincing, indeed the terraces not exhibiting in their conformation other features than those which are readily explained by fluviatile action in working over and rearranging the loose materials accumulated along the base of the mountains. Local glaciers may have and doubtless did occupy the gorges that so deeply score the Téton and opposite mountain ranges; but one, in the course of a hasty visit, seeks in vain for those indubitable signs which are the conspicuous infallible records of former glacial action in other regions. This absence of scoring and grooving, the concomitants of glaciation, may not seem so strange on maturer reflection, especially when we take into consideration the potency of simple-acting atmospheric influences, which involve in their effects far more significant results than the feebly engraved records of the reign of the glaciers.

These high terraces terminate along Fighting Bear Creek in steep declivities 40 to 60 feet in height, reappearing at intervals lower down the valley, but less and less conspicuous, while to the north the reverse is true, the terraces increasing in magnitude, especially in the debouchures of the principal gorges where they have formed barriers 500 feet above the present level of the Snake, behind which nestle pretty lakelets, which Professor Bradley refers with good reasons to morainal origin. So far as the present observations extend the local character of these accumulations is manifestly apparent in the nature of their components; the west-side terraces being almost exclusively made up of granitic, gneiss, schists, and quartzite bowlders, with, as has before been mentioned, reddish buff laminated sandstone and limestone *débris* prevalent in the later-formed benches, as along East Pass Creek in its passage across the higher benches. Above the confluence of East Téton Creek a high terrace sets in, which forms an extensive grassy plain 200 feet and more in height above the river, gently rising to the west, where it is bordered by the before-mentioned wooded morainal ridges, which latter, in places, project far out into the basin south of Jackson's Lake. Professor Bradley has given a profile of this portion of the valley, from levellings made by Mr. Hering, from which we gather a more correct knowledge of its contour than is apparent when viewed at a distance from the east side of the valley. This profile is incorporated in an accompanying plate of diagrams, which sufficiently explains those features of surface reliefs dependent on the character of the superficial materials which fill the basin south of Jackson's Lake.

On the east side of the basin there exists a greater diversity in superficial contour, in part due to the presence of island-like remnants of sedimentary formations and eruptive effusions, but mainly to the modifying changes wrought in the superficial deposits by considerable tributaries which flow out into the basin from the eastern highlands. The more important of these are the Gros Ventre, Elkhorn, and Buffalo Fork; but there are other smaller water-courses which have effected marked local changes in the materials in the way of their channels, and which have thrown the ancient terrace into much confusion, eroding shallow basins and building up low terraces of their own out of the materials which they have swept down from the neighboring hills. This is true of the Little Gros Ventre, and several small streams that drain the western flank of Mount Leidy highlands between the Gros Ventre and Elkhorn. Out of the old terrace the former stream has formed an abrupt barrier along its right bank, 100 to 150 feet high, its face thickly strewn with bowlders and pebbles. This barrier slopes off on the northwest in a long glacis to

the Gros Ventre, where it terminates in low benches less than 20 feet above the stream, a couple of miles above its mouth. To the south it soon merges into the eastern face of the group of low hills belonging to the Lower Gros Ventre Buttes, and where the barrier of the chafing brook is formed of early Palæozoic rocks. On the Gros Ventre below its debouchure, a series of more regular terraces is met with, with remnants of the ancient terrace appearing on the south, where it is 100 feet or more above the stream, and partly encircles the low Tertiary hills, on which erratics are occasionally met with at a much higher elevation.

To the north of the Gros Ventre the ancient terrace, at first much cut up by minor water-courses, gradually assumes its pristine condition, forming a broad, grassy, outlying glacis, bordering the wooded Tertiary foothills of the Mount Liedy highlands, and terminating in a line of bluffs hemming the east side of the Snake Bottoms, and which as suddenly breaks down in steep declivities south of the debouchure of the Elkhorn. Its surface in the immediate vicinity of the foot-hills is modified by a series of low benches which run out diagonally into the basin, erosion having swept away the finer materials, leaving long trains of rubblestones. Farther south, however, the light brown surface soil is generally prevalent, here and there patches of light marly soil and limestone fragments appearing in the midst, indicating subjacent late Tertiary deposits. The coarse materials of this portion of the terrace show a variety of rocks, chiefly quartzite, with rarely bowlders of volcanic rock.

Between the broad basin-like debouchures of the Elkhorn and Buffalo Fork, which are paved with water-worn bowlders, and interspersed with meadow-flats and willow-fringed beaver-ponds, projects a tongue of low Tertiary upland, which is enveloped in a heavy mantle of drift-like deposits. There is also here found a deposit which seems to be of Quaternary age, composed of yellow earth and pebbles arranged in layers, sometimes forming a homogeneous mass, the surface strewn with bowlders. In places, as in the bluffs on Elkhorn Cañon, and elsewhere in this upland, a dark brown soil deposit is observed, probably the slow accumulation during the time the waters of the Snake occupied a much higher level than at present.

The incipient terraces which are to-day in process of formation over the wide-spreading beds of some of these little streams offer most interesting subjects to detain the observer. We here see going on, in miniature, the same fluvial actions to which are ascribed the various phenomena observed in connection with the terrace formations of more ancient date. But these later manifestations show the impotency of the currents of the present streams, even in times of freshet, to wield the heavy materials in their path; hence their channels show a tendency to spread laterally instead of confining and deepening their beds in the loose materials over which they flow.

Above the Gros Ventre we encountered the remains of a ditch, which, it is said, was constructed some six or seven years ago for the purpose of conveying water to some placer mines opened in the gravels in the lower bottom level. What success attended this enterprise we are unable to learn. "Prospect pits" were found at several places in the valley, which is periodically resorted to by small parties and solitary individuals in quest of gold and adventure. Possessing a fertile soil and an abundance of water, nought but its northern latitude (near the 44th parallel), its altitude (6,500 feet), and the consequent shortness of the season, prevent this becoming a prosperous agricultural district. During the time of our visit (latter part of August) heavy frost was of daily occurrence, ice forming an eighth of an inch thick overnight in the camp utensils;

indeed, more agreeable temperature was experienced at our mountain bivouacs than in the valley. The pasturage, however, is excellent; and at seasons the woods and plains are stocked with game; elk, deer, antelope, and bears abound, while in the forests two or three kinds of grouse are found, and the streams afford abundance of large, delicious trout.

Just within the mouth of the Gros Ventre Valley several small rivulets of warm, slightly saline water were discovered flowing into the stream on either bank. They are fed by springs which appear in marshes in the bottom land half a mile or so above the point where the river enters Jackson's Basin. The inflowing spring waters seem to perceptibly raise the temperature of the river water below the point where they issue into the Gros Ventre, from which it may be inferred their volume is considerable. These springs probably have their sources in, or issue from, the Carboniferous limestone, bluffs of which line either side of the narrow valley at this point.

Sedimentary and volcanic rocks.—We now come to certain small and isolated areas of older sedimentary formations properly belonging to the basin, and in the brief subjoined notice will also be included mention of such comparatively inconspicuous volcanic deposits as are met with in patches disconnected from the great flows which hem in the head of the valley to the north.

In the somewhat narrowed southern half of the basin two groups of low, grassy hills rise from the plain to the height of a few hundred feet, and which are chiefly conspicuous for their isolation. These are known as the Upper and Lower Gros Ventre Buttes. The lower and larger group lies between the Snake and Little Gros Ventre Creek, just below the confluence of Gros Ventre River, and consists of a series of low hills penetrated by narrow, shallow, parallel depressions, in a northerly and southerly direction, or corresponding approximately to the direction of strike of the sedimentary deposits which enter largely into their composition. At the northwest the hills culminate in a bolder eminence in which dark, rusty volcanic ledges appear, extending southward in a low spur. These Professor Bradley found to consist of "red, gray, black, brown, and variegated porphyritic breccias, including much jasper, but partly porous, loose-textured, and even ashy. The beds are much distorted, but have a general northwesterly dip." Similar deposits were noticed rising gently southeasterly in the eastern portion of the group, where they are underlaid by heavy deposits of dark-weathered limestone, probably of Quebec age. The latter beds appear in the steep bluff along the west side of the Little Gros Ventre, facing a prominent spur of the Gros Ventre Mountains, which juts out into the valley at this point, the beds dipping at a moderate angle northwestward. At the south end of this group Professor Bradley observed in a low sharp butte horizontal beds of gray limestone, which were compared with the Carboniferous. The interval between the east and west portions of this group comprises a shallow undulating depression, which may be partially filled with soft Tertiary deposits, over which is spread a mantle of Post-Tertiary materials.

About eight miles northeastward of the above buttes, a similar but smaller cluster, called the Upper or North Gros Ventre Buttes, occupies the interval between the Snake and Gros Ventre Rivers. In the northern and higher portion of this group Professor Bradley saw exposed a fair representation of the Palæozoic series of the region, consisting of "gray quartzitic sandstones, which are probably of Potsdam age," overlaid by conglomeritic limestones so characteristic of the Quebec Group, as developed in the Téton Mountains, and these in turn fol-

lowed by limestones abounding in Carboniferous fossils. The latter deposits, which exhibit the best exposures, dip N. 56° E., at an angle of about 70°. In the west face of the butte Professor Bradley mentions the occurrence of "Post-Tertiary whitish sandstones and marls, inclosing fragments of limestone and chert, but no fossils, of which all the southern part of the butte is composed." As seen from the hills to the northeast, these light-colored deposits apparently form a low outlier on the northeast flank of the butte, while the southern spur of the butte is apparently made up of brown deposits with indurated layers, dipping in the same general direction as the other Tertiary deposits, or northwestwardly.

In the space included between the Gros Ventre River and the western foot of the adjacent mountains of the same name, to the southeast of the Upper Gros Ventre Butte, a considerable area is occupied by low, beautifully curved grassy hills, 500 to 700 feet above the Snake, and which are connected with the mountain border by a shallow depression or saddle. This area is intersected by parallel depressions having a northeasterly and southwesterly general direction, on the crest of one of the highest ridges of which was located Station XLV, commanding an extensive and beautiful view of the southern portion of the basin and the majestic peaks of the Têtons. These hills appear to be made up of light ash-colored, marly clays and dark, shaly deposits, with bands of soft, more or less porous, thin-bedded, cream-colored limestone. There may also be arenaceous beds, but the prevalent colors are as indicated. Near Station XLV the limestones outcrop in the brow of one of the east ridges, where they dip 30°, W. 25° N. Although diligent search was made for organic remains in these deposits, none were found, save a few indistinct molds of tubular bodies; but in their lithological characters they strikingly recall the late Tertiary deposits occurring in the southwestern section, in the Blackfoot Valley and near Fort Hall. These deposits extend across the depression east of Station XLV, and apparently recline on the foot of the mountain, which is here flagged with heavy-bedded magnesian limestones, either of Carboniferous or Niagara age, as though their inclination was determined by elevatory forces situate in the Gros Ventre Range, though it was not the same force that folded the more ancient deposits, as is shown both by their strike and more northerly inclination, as well as their evident non-conformity. To the south of the latter locality these Tertiary deposits rest upon Quebec Group limestones, while to the north they successively lap up on Carboniferous, the Triassic (?) "red beds," and finally appear to merge into the older Tertiary in the western foot-hills of the Mount Leidy Group, as will hereafter be described.

To the north of the debouchure of the Gros Ventre these Tertiary deposits are far less conspicuous within the limits of the basin proper, although they appear here and there from beneath the terrace accumulations, indicating their subjacent presence. Professor Bradley, however, mentions in the vicinity of the confluence of Buffalo Fork and the Snake exposures of "gray and buff, fine-grained, shaly sandstones of indeterminate age, dipping sharply to the southeast," though at one point the "dips are much confused." At the lower end of Jackson's Lake, he remarks the occurrence of "high knobs of porphyries and trachytes, which indicate, by their position, at least a former connection with the more northern beds, which were traced to within five miles of the northern end of the lake." Seen from the opposite side of the valley, to the southeast, these knobs have the appearance of a cluster of buttes occupying the interval in the eastern bend of the Snake. In the abrupt eastern

face a heavy ledge of dark-brown rock shows a conspicuous band, dipping westward at a moderate angle, apparently inclosed in brown earthy deposits. It may be that the indurated dark ledge is an intrusive sheet of volcanic material; but the brown inclosing deposits recall similar-looking beds in the south spur of the Upper Gros Ventre Butte, while the latter may possibly prove to be identical with extensively exposed brownish deposits in the neighboring hills to the northeast of the Snake, and which also occur in the Mount Leidy Group to the southeast.

A few hundred yards west of Station XLVII, which occupies a low drift-covered ridge on the south side of Elkhorn Valley, a low knoll near the end of the ridge, 300 or 400 feet high, is crowned with an isolated mass of dark-green volcanic rock, weathering reddish like trachyte, though it is porphyritic in character. It shows more or less distinct bedded structure, and dips to the northwestward at angles of 15° to 20°. It seems very probable that this ledge may be identical in character with the before-mentioned dark-brown ledge in the butte south of the outlet of Jackson's Lake, with which it also agrees in the direction and angle of inclination; but at the present locality the character of the inclosing deposits was not ascertained. Its position, however, indicates that it either belongs to a flow overspreading or alternating with sedimentary materials, or a sheet of volcanic matter intruded between the layers of sedimentary deposits.

THE GROS VENTRE RANGE.

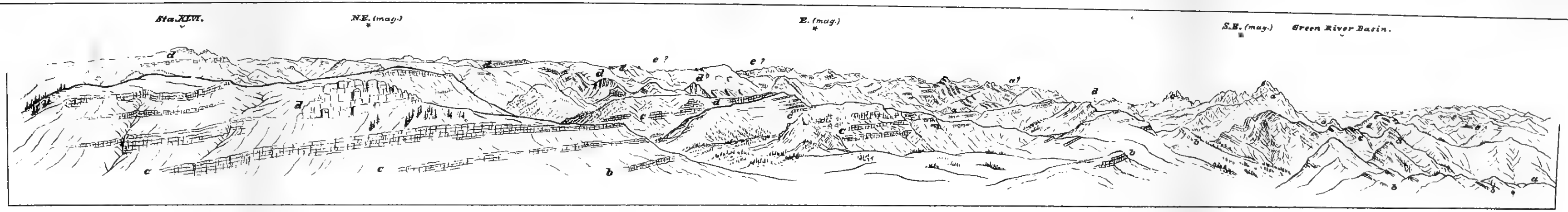
The belt of highlands known under the several appellations Gros Ventre, Green River, and Wyoming Mountains forms a well-defined mountain range extending westward from a point about opposite Union or Warm Water Pass, in the Wind River Mountains, 40 to 50 miles, when it terminates in an exceedingly rugged mountainous region overlooking Jackson's Hole, above the Grand Cañon of the Snake. Its width here, including the area between the Gros Ventre on the north and Hoback's River on the south, is in the neighborhood of 20 to 25 miles; but to the east it apparently narrows, and at the same time appears to be less scored with profound gorges such as have been carved out of the western portion. This western front presents a variety of topographic and geological features, such as find ready explanation in the nature of the component rocks; almost ideally perfect Archæan peaks and rounded abrupt-terminating spurs, contrasting with the peculiar sweeping foreland and block-like craggy-weathered summits, of scarcely inferior altitude, fashioned out of uplifted sedimentary formations. This broad western end of the range is deeply penetrated by the Little Gros Ventre, which, with the attendant erosion of numerous lateral ravines, has unlocked a vast extent of the interior portion of the range, revealing for satisfactory study its general structural features. As our own examinations were confined to this part of the range, we may be permitted to repeat with some minuteness the observations there made. Of the southern flank, or that belonging to the drainage of Hoback's River, we can only speak in general terms; but of the region to the east, on the headwaters of Green River, and also on the opposite slopes descending to Gros Ventre River, we have in the report of Dr. Hayden of Capt. W. F. Reynolds's expedition (1860) many and most important details respecting the character and distribution of the geological formations in that quarter.

Approaching the range south of the debouchure of the Little Gros Ventre, the long foreland slope is flagged with Quebec Group limestones, with here and there remnants of heavy-bedded magnesian limestone, the latter appearing in greater force in the foot-hill benches to the north,

Plate XXXIX.

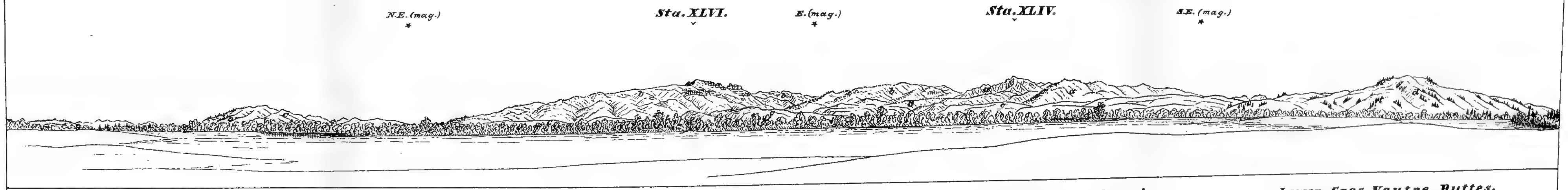
nge, fr
d

ntre Ra Buttes.
Snake



Gros Ventre Range, from Station XLIV.

a. Archœan. b. Quartzite. c. Silurian. d. Carboniferous, including Niagara (?) e. Triassic red beds.



West Flank of the Gros Ventre Range, from Jackson's Basin.

Upper Gros Ventre Buttes. Lower Gros Ventre Buttes.

a. Archœan. b. Palæozoic. Snake River. c. Tertiary. d. Volcanic.

where it replaces the Quebec in the mountain-flank. To the south, however, a high Archæan spur, carrying on its ridge a plating of quartzite, and probably, also, Quebec limestones, breaks the continuity of the foreland slope and abruptly terminates in steep declivities facing the eastern escarpment of the Lower Gros Ventre Buttes. To the south of this spur a few miles, as we shall see presently, the mountains are largely made up of an enormous development of red deposits, sandstones and arenaceous shales, beneath which Professor Bradley noted the occurrence of limestones, probably of Carboniferous age, which, still farther south, merge into the Carboniferous deposits at the head of the Grand Cañon of the Snake.

Passing up over the foreland north of the above-mentioned spur to the summit of the isolated peak on which Station XLIV was established, the northwest flank of the mountain exhibits the section shown in the accompanying plate. At the foot of the ascent, the Quebec limestones show in ledges lapping up on the slope. They consist of (3 *c*) drab, even and thin-bedded, rough-weathered, fragmentary layers, underlaid by (3 *a*) a similar heavy ledge, separated by (3 *b*) bluish-drab, partially indurated shales, all dipping 25° to 35°, W. 50° N. In the deeper ravines ledges of rusty-red quartzite and hard, laminated, reddish-buff and pale pink and cream-colored sandstones appear (2) dipping 30° to 40° northwestward, and which, higher in the slope, form the crest of the ridge along the north side of the cañon which rises in Station XLIV, separating this from the before-mentioned high Archæan spur. The latter deposits hold the position of the Potsdam quartzites. Still higher in the slope a slight fold in the strata was observed, and just beyond this a limited outcrop of (4) light buff magnesian limestone occurs, in which a few very imperfect fossils were found, crinoidal remains and *Hemipronites*-like brachiopods. This, doubtless, is a remnant occupying a slight sag in the undulating strata, and, judging from its lithological appearance, it may either belong to the Niagara or Carboniferous. Above the latter exposure the surface shows immense quantities of quartzite *debris*, and, as we ascend, gneissic fragments become more and more prevalent, until, finally, their native ledges are reached in the immediate foot of the peak of Station XLIV. The angular quartzite and but little abraded gneissic *débris* is piled in huge ridges, like morains, which, for the most part, are covered with a dense forest of pines.

The northwest face of the mountain shows an amphitheatre, in the bed of which deep banks of snow lay, from which trickled pretty rivulets, watering cosy mountain meadows dotted with the many hued blossoms of tiny, moss-like plants. A sharp Archæan spur defines the eastern wall of the amphitheatre, its crest weathered into pinnacles, and buttressed by the peculiar weathered forms common to these rocks. Their bedding is much contorted and obscure, though it appears to dip moderately northeastward.

Ascending the abrupt-falling western spur leading to the summit, 700 to 800 feet higher, heavy blocks of a light-gray quartzose gneiss are encountered, showing breakage or cleavage structure in two marked planes, the one inclining north at an angle of 40°, and the other S. 45° W., at angles of 70° to 80°, the laminated structure being extremely obscure, and only as seen in mass does it exhibit what appears to be the true bedding, inclined as before stated, northeastward. The process of degradation by which these hard Archæan rocks are reduced to the condition of finely pulverized soils is well displayed at this locality; and wherever a little platform allows the retention of the soil thus derived,

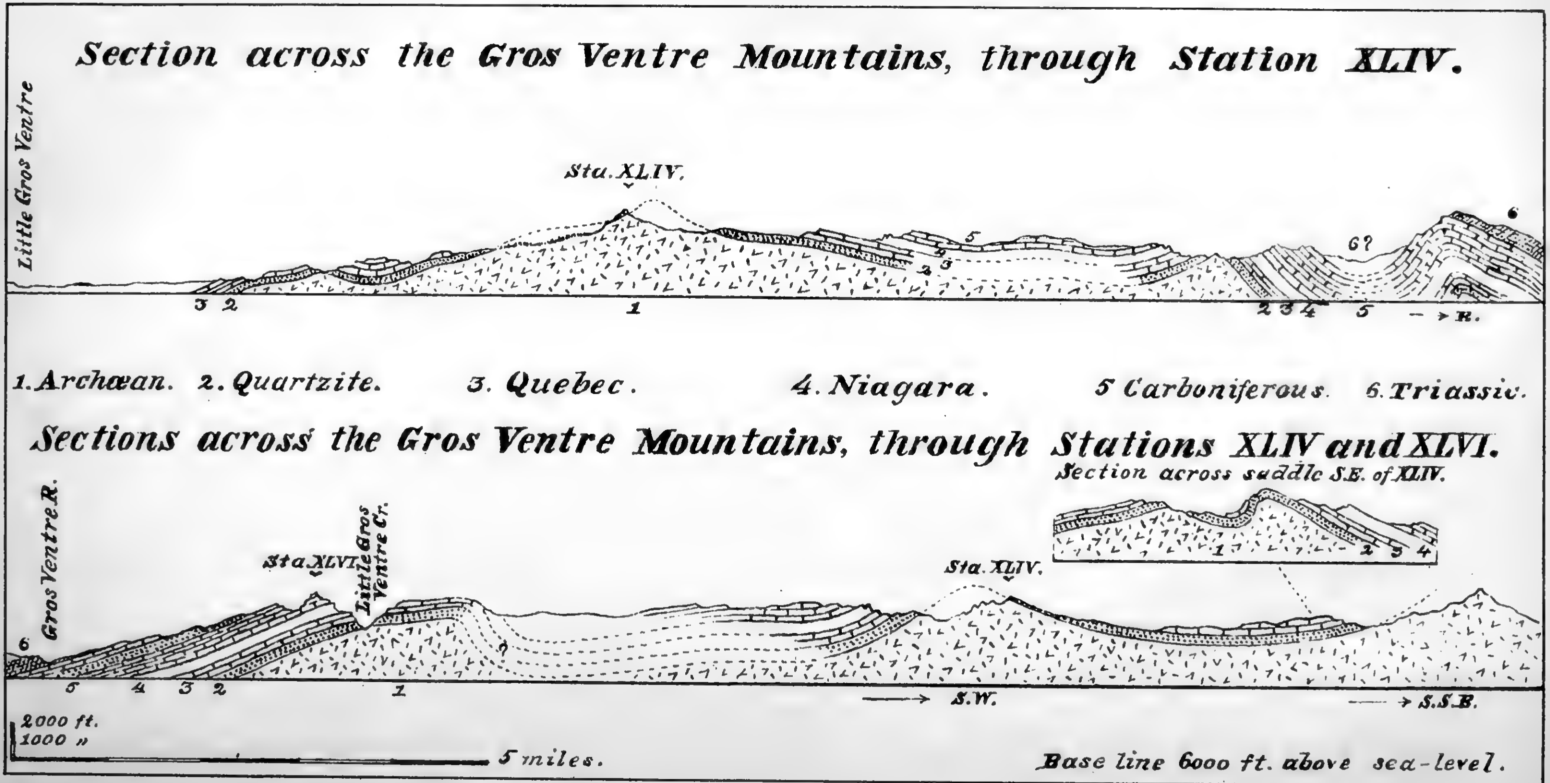
Alpine plants spring up, which have contributed vegetable matter and transformed the little basins into accumulations of rich loam.

At a point near the summit reddish gneiss appears dipping about W. N. W. at an angle of 20°. It is overlaid by a grayish-white intensely hard quartzite, which shows at one point an inclination N. 30° E., at angles of 35° to 40°. A few yards south of the summit the white quartzite dips 15°, S. 45° E. It is conglomeritic in places, laminated and cross-bedded, pinkish above and below, probably the prevalent color, attaining an exposed thickness of at least 50 feet. The summit of the mountain is a confused mass of angular blocks of this rock, in which a few obscure fucoid-like markings are observable. Intercalated between the quartzite and the gray gneiss occurs a layer of beautiful pink-red, very quartzose gneiss, like that mentioned in the northwest side. There are many varieties of gneissose and schistose rocks in the mountain, intersected by granitic and quartz veins, and these deposits have been much broken up and recemented, forming a sort of coarse breccia. From the above will readily be inferred the greatly-disturbed condition of the Archæan nucleus of this portion of the range. As time did not permit carrying our work into the heart of the range, to make up for the deficiency as far as possible, a rather detailed notice of the geological appearances presented from this elevated outlook is here appended.

Station XLIV attains a height of about 4,000 feet above Jackson's Basin, and is the westernmost culminating peak of the range, situate about midway between the Gros Ventre and Hoback's Rivers, commanding extended views of the surrounding country. From the north, east, round to the south, the Gros Ventre Mountains are spread out in a grand panorama; the remainder of the circle comprehending the Tétons and the beautiful plain of Jackson's Basin, with, to the north, part of the low, much eroded tertiary hills that occupy the angle north and east of the Buffalo Fork and Snake River. To the northeast, about eight miles distant, the western foreland sweeps up from the level of Jackson's Basin into the shattered sedimentary crown of Station XLVI, which, with its easterly continuation, shuts out the view to the northward, save here and there loftier distant mountain crests. Intermediate, perhaps one to two and a half miles from XLIV, a lower but still high ridge shows heavy ledges of Quebec Group limestones, capped by the more massive-bedded limestones, probably of Niagara age, the base of the sedimentaries being composed of the Primordial quartzites, whose rusty-reddish *débris* strews the lower declivities descending to the light-gray Archæan floor of the amphitheatre which separates the latter ridge from Station XLIV.

This ridge is abruptly terminated on one of the tributary branches of the Little Gros Ventre from the south, and just beyond a glimpse is caught of a low crown protruding in the slopes facing Station XLVI, which also appears to be composed of Archæan rocks, the sedimentaries having been denuded over an inconsiderable area. The ground here referred to constitutes one of those great tilted blocks of sedimentary strata, the exact counterpart of the foreland on the west flank of the Téton Range, the slope descending gradually to the level of Jackson's Basin, the strata dipping at a somewhat steeper angle in the same direction, so that, in the debouchure of the Little Gros Ventre, the heavy-bedded, rough-weathered magnesian limestones, Niagara or Carboniferous, appear in uplifted outliers in the foot of the mountain. There is, however, this distinction: that, in the western flank of the Gros Ventre Range, besides the great uplift, the strata were thrown into quite conspicuous minor folds, which will be noticed more at length further on.

PLATE XL.


Section across the Gros Ventre Mountains, through Station XLIV.
Little Gros Ventre
Sta. XLIV.
6?
6
3 2
1
2 3 4
5
→ E.
1. Archæan.
2. Quartzite.
3. Quebec.
4. Niagara.
5 Carboniferous.
6. Triassic.
Sections across the Gros Ventre Mountains, through Stations XLIV and XLVI.
Section across saddle S.E. of XLIV.
1
2 3 4
Gros Ventre R.
Sta. XLVI.
Little Gros Ventre Cr.
Sta. XLIV.
6
5 4 3 2
1
→ S.W.
→ S.S.E.
2000 ft.
1000 "
5 miles.
Base line 6000 ft. above sea-level.

To the northeast of Station XLVI, in the opposite face of the deep broad gorge in that direction, the strata, Carboniferous, form a low arch. Following along this high ridge, which is apparently the same that forms the north flank of the range along the south side of the mountain course of Gros Ventre River, to a point about east-southeast of XLVI, the escarpments defining the deep drainage channels reveal at intervals magnificent sections of the sedimentaries in connection with a remarkably uniform uplift which appears to hold about the same magnitude throughout the extent indicated, as seen from Station XLIV. Along the south or southwest flank of this fold the strata plunge steeply, in places vertical, elsewhere flagging gigantic ridges. But in the opposite slope the same deposits dip much more gently in the direction of the Gros Ventre Valley, and appear to be faced with an extensive development of "red beds," whose edges often appear in the crests of the huge ridge, which shows in places the whole Palæozoic series, even the Archæan nucleus appearing in low outliers in the bottom of the intermontane valley.

The northwestern terminus of this anticlinal fold, or such as the erosion of Jackson's Basin has determined it to be, apparently lies to the south of the débouchure of the Gros Ventre River, where its appearance will be described in connection with the notice of the observations in the vicinity of Station XLVI. In this part of the range the lower intermediate ridges to the eastward are mainly made up of the Silurian limestones and quartzite. The former show the rusty weathered exposures so characteristic of the Quebec Group beds in the Téton Mountains, while the superimposed magnesian limestones are accompanied by overlying red-stained limestones with shaly partings so frequently associated with the exposures of the Niagara and the inferior member of the Carboniferous in the same region. These strata dip gently to the east or northeastward off the crest of the uplift, whose axis at one point culminates near the present summit of Station XLIV.

Towards the southeast these beds gently rise, where they appear low on the slope descending from a still more lofty and rugged Archæan peak some five miles about south-southeast of Station XLIV. A very irregular deep saddle connects this peak with XLIV, which bears for a part of the way a covering of Silurian beds dipping quite steeply south or southeastward, in which direction they are followed by the Carboniferous limestones, and in the extremely broken region still beyond, stretching across what has the appearance of a profound narrow valley which here intersects the mountains, an enormous development of pale and deep-red strata occurs, the structural features of which, however, it was impossible satisfactorily to make out.

On the northeast flank of this high Archæan peak an interesting flexure in the Primordial rusty buff beds is finely displayed, the nucleal rocks showing all the peculiar features of weathering characteristic of the Archæan series. This latter fold is in line with the above peak and Station XLIV, and doubtless pertains to the same general uplift. The Station XLIV uplift differs from that previously mentioned a few miles to the northeast, and with which it is probably more or less parallel, in the less regular distribution of the forces that caused the disturbance, and which, but for the immense erosion which has bared its real character, might be mistaken for so many local quaquaversals or a bulging of the sedimentary beds. While, indeed, a section carried along the saddle from one peak to the other represents a broad synclinal depression filled with sedimentary deposits, a transverse section across the saddle ridge also reveals its anticlinal structure, and at the same time its probable intimate relations to the culminating peaks which mark the sites of the

more intense manifestation or local concentration of the same elevatory forces.

Mention was made of the great spur to the west of Station XLIV, whose abrupt terminus fronts the eastern escarpments of the Lower Gros Ventre Buttes. This ridge is seen to be heavily burdened by the older sedimentaries which occupy a shallow sag between the above-mentioned saddle and its high western point, which latter appears to be partially flagged with quartzite, and corresponds to the sharp fold noted in making the ascent of the foreland ridge north of this spur. Hence, it would seem very probable that we have here another and parallel uplift which culminated in the great spur, to the northwest of which it is far less conspicuous, and may gradually diminish and finally die out; in the opposite direction its character could not be clearly ascertained. All these folds have a general parallel arrangement, trending about southeast and northwest, approximate.

Along the northern or northeastern border of the range, there appear the edges of great blocks of tilted strata, showing the gray of the Carboniferous limestones, and the peculiar colors of the "red bed" series, the disposition of which is exactly that of their occurrence in the northeast flank of the Wind River Range, whose snow-covered domes just rise to view far away to the south of east. Southeastward of the high Archæan peak, the main crest of the range, or such it appears to be, along the southern border, is soon surmounted by the sedimentaries, quartzite, and Quebec Group limestones, which dip gently northeastward into the depression at the foot of the great northern fold. The southern flank of this crest was at no point visible, so that we do not know whether it presents an abrupt pitch of the strata similar to the corresponding flank of the northern fold, or the beds more gradually descend into the basins at the heads of Hoback's and Green Rivers, in which latter, to the eastward, in the neighborhood of Union Pass, Dr. Hayden found extensive developments of the Tertiaries rising high up on the western flank of the Wind River Mountains.

To the south-southeast the view embraces a vast extent of haze-obscured country, devoid of prominent orographic features, and which evidently belongs to the Green River Basin. To the south and south-southwest massive mountain ridges define the horizon, their summits showing large patches of snow, and which form the southern extension of the Snake River Range between Hoback's and Salt Rivers. From the eastern border of this mountain belt a dark, even-crested, gradually diminishing ridge extends far out into the above-mentioned basin region. It resembles the great volcanic plateau slopes north of the Téton Range, but Dr. Peale, in whose district it lies, found it to be made up of Green River and Wasatch Tertiary. The Snake River enters the Grand Cañon to the south-southwest, and is soon lost amidst a labyrinth of deep gorges and rough mountainous country. Southeast or east of the upper entrance the Grand Cañon a rather low but very broken group of mountains, traversed by rugged gorges tributary to the Snake, seems to be entirely composed of deep red strata, disposed in broad belts, beyond which are seen grayish deposits in the main mountain crests, which are probably Carboniferous limestones, upon which the red beds rest. The latter are the deposits mentioned by Professor Bradley as forming three well defined anticlinal folds in the upper third of the Grand Cañon below the mouth of Hoback's River. The trend of these anticlinals is, however, more to the south than that of the Gros Ventre folds, giving rise to the narrow triangular area which separates the latter from the Snake River Range. In the belt belonging to the southern or southwestern flank of the Gros

Ventres there are indications of a sharp anticlinal fold, by which the red beds are lifted into high crests north of Hoback's River, but which may prove to belong to the southeastern extension of the before-mentioned fold west of Station XLIV.

The relations of the folds and involved sedimentary formations observed by Professor Bradley in the Grand Cañon of the Snake to similar phenomena and stratigraphical elements met with in the northwestern extension of the Snake River Range have been briefly discussed in a preceding chapter. The relative age of mountain elevation is always a subject of prime importance, and, in a region like the present, it is sure to draw the attention of the observer to every fact which seems to have a bearing, near or remote, toward the solution of a problem which is so constantly before the mind. In this connection, it seems as though we have in the disturbed late Tertiary deposits within the area of Jackson's Basin at least a hint as to the comparatively modern date of the elevation, or one of its latest phases, of the Gros Ventre Range, and, inferentially, the relatively more remote date of the disturbances which resulted in the upheaval of the Snake River Range to the southwest. The evidence here observed is almost precisely the same as that furnished by the variegated Tertiary deposits in the lower valley of the Snake on the opposite side of the latter range, which lie tilted unconformably, on the border of the opposed Caribou Mountains.

As has before been mentioned, our knowledge of the geological structure of the eastern portion of the Gros Ventre Range is derived from the observations of Dr. Hayden, in 1860.* Dr. Hayden mentions, on the upper waters of the Gros Ventre, extensive developments of lignite-bearing Tertiary deposits, and lower down the valley successively appear Cretaceous, Jura, and Triassic deposits, which recline on the northern flank of the range. The Mesozoic formations doubtless pass out into Jackson's Basin, north of the débouchure of the Gros Ventre, where, however, they are covered by late Tertiary beds, and even in the rounded foot-hills on the border of the basin they are so concealed beneath detrital materials as to escape detection.

The distribution of the late Tertiary deposits in Jackson's Basin has already been alluded to, as also their upraised position on the flank of the mountain north of the point where the Little Gros Ventre leaves the hills. This mountain border exhibits the heavy-bedded, rough-weathered magnesian limestone, so like the Niagara, but no fossils were observed here by which its age might be established with certainty. As we pass northward, however, these beds are lost to view in a recess a few miles south of the debouchure of the Gros Ventre, but soon reappear, and finally pass beneath the Carboniferous deposits across which the stream has eroded a narrow valley in its passage into the basin. The latter deposits, as exposed in the south angle of the debouchure, are made up of dark-brownish drab, porous, magnesian limestone, dipping 15° to 20°, N. 5° E. It occurs in heavy beds, and would make an excellent building material. It weathers much like the buff magnesian limestones referred to the Niagara, from which it is distinguished both by its darker color and the prevalence of crinoidal columns, a *Spirifer* and *Hemipronites crenistria*, all Carboniferous forms. These magnesian beds are overlaid by dark-gray limestone, also charged with *Hemipronites* and a small *Athyris*, &c., and which appear in a low bluff escarpment on the opposite side of the stream a short distance above, dipping in the same direction, and overlaid in turn by light-gray limestones rising up on the northern flank of the Gros Ventre Mountains. These exposures are often covered with a lichen-growth,

*Reprint, Report U. S. Geol. Survey, 1872, chap. I.

which gives to the ledges a beautiful orange-reddish tint seen at a distance.

Looking up the Gros Ventre Valley, the limestones are soon succeeded by a heavy series of red arenaceous deposits, which continue several miles along the north side of the stream, and which, in part at least, are the same mentioned by Dr. Hayden. This point was also visited by Professor Bradley, who reports the following section a short distance within the valley, on the north side:

Section in the debouchure of the Gros Ventre Valley.

"1. White, friable, false-bedded sandstones, 10 feet.

"2. Covered space, about 100 feet.

"3. Irregularly-bedded, pale-gray and buff, partly bituminous, magnesian limestones, 50 to 60 feet.

"4. Pale-red friable sandstones, darker and shaly below, 300 to 350 feet.

"5. Compact, fine-grained, gray sandstone, 15 to 20 feet.

"6. Brown, coarse, friable, false-bedded sandstone, 60 to 80 feet.

"7. Coarse, friable, red sandstone, 40 to 50 feet.

"8. Compact, dark-drab, fossiliferous limestone, 300 to 400 feet."

The bed No. 1, Professor Bradley refers to the late Tertiary; No. 3 is provisionally referred to the Jurassic, although no fossils are observed in this horizon; No. 4, Triassic; and No. 5–8, Carboniferous.

The second and last visit to the higher portions of the range was made in the ascent of the mountain chosen for the topographical Station, XLVI. This occupies a commanding summit at the northwest end of the range, about 10,500 feet above sea-level, from which the view overlooking the lower portion of the Gros Ventre Valley, and a part of the Little Gros Ventre Valley in the opposite direction, is particularly interesting and instructive. Keeping the crest of the main foreland ridge, the way lies over Carboniferous deposits the whole distance between the foot of the spur just south of the debouchure of the Gros Ventre and the summit, along a general southeast course of about six miles. The first two miles is a rather steep ascent of about 2,500 feet, flagged with light and dark-drab cherty limestone, with hard brittle siliceous layers. The limestone contains numerous characteristic fossils, conspicuous among which are the usual forms of *Zaphrentis*. Gaining the northwest shoulder of the spur, the remainder of the way lies along the broad crest of the ridge, with a gradual and quite uniform rise to the foot of the culminating peak, the last 400 feet in the ascent being abrupt.

The southern or southwestern slope of the ridge is deeply furrowed by numerous short ravines tributary to the Little Gros Ventre, that render this aspect exceedingly broken; but on the northeast the slope is more gradual, although it is also much cut up by drainage channels, falling with the dip of the strata, which is a little east of north, though the direction is variable, at angles of 15° to 30°. For a considerable distance the crest of the ridge nearly corresponds to the strike of the limestone strata, when it bears a little more to the south, and at the same time rapidly rises into the bare Alpine heights, where the fir trees are gathered in beautiful clumps, and the soil, based upon remnant patches of red arenaceous deposits, decked with many bright blossoms.

The summit of the mountain forms a short north-south ridge, rounded on the west side to the escarpments of the buff-gray magnesian limestones which skirt this side of the mountain, overlooking the gorge-like

valley of the Little Gros Ventre, and which are so well displayed from Station XLIV. The northeast face of the peak breaks down in sheer precipices of dark-weathered limestone into an amphitheatre, which is divided into two nearly equal parts by a huge buttress that projects from the main peak, carrying on its crest curiously weathered pinnacles and towers of limestone, terminating in a conical point. The amphitheatre is filled with banks of snow, which feed the tiny lakelets that nestle at the foot of the *débris* slopes. To the east the peak is rent and fissured by the action of the elements, placing an almost impassable barrier between the station and the lower crest in which the mountain ridge is terminated above the saddle separating the drainage of the two Gros Ventres.

The summit of the peak is strewn with angular limestone fragments, which, in places, are tumbled into funnel-shaped sinks; no erratic materials were observed. It is made up of drab limestone interbedded with dark brownish-drab magnesian layers and yellowish weathering deposits in the lower portion, and abounding in fossils, *Hemipronites crenistria* being particularly numerous in certain layers, besides a large *Spirifer*, *Athyris*, *Zaphrentis*, &c. These beds dip at an angle of 15°, W. 30° N. to N. 5° W. In the northwest foot of the peak they incline at about the same angle, N. 40° E. to N. 5° W., and at one place bulged up into a slight anticlinal or undulation, with a westerly dip of about 10° on the one flank.

In the sloping ridge which forms the western wall of the gulch that flows down to the Gros Ventre to the northward, the Carboniferous limestones are overlaid by a series of arenaceous deposits, consisting of intensely hard, pinkish siliceous beds and hard, laminated, grayish, reddish-stained sandstone, including bands of red and yellowish sandy shales, which impart to the exposures so strong a Triassic aspect. But these deposits are precisely like the upper beds of the Carboniferous in the Téton and Snake River ranges to the west, in which latter region they are known to be succeeded by later-formed limestones, whose organic remains establish their Carboniferous age. These Carboniferous red beds are doubtless identical with the lower red-bed series in the debouchure of the Gros Ventre, which were described, as above quoted, by Professor Bradley, where they were estimated at 400 to 500 feet in thickness. The same beds also appear in the east side of the above-mentioned gulch, capping the limestones, which slope off at a moderate angle northward in the declivity which forms the Gros Ventre or northern face of this part of the range; and still farther east a heavy mass of deeper red-colored strata appears, borne upon the flank of the mountain, their edges shown in escarpments facing southward. The latter deposits are doubtless the same as those noticed by Dr. Hayden in the valley of the Gros Ventre, where they are associated with thin bands of gypsum.

To the southeast this northern barrier ridge shows a sharp fold, the limestones flagging the south-facing slope, and which probably is part of the great fold seen from Station XLIV. It is possible that the belts of red deposits seen at various points within the range belong to the Triassic "red-bed" series, which were curved over the great fold, but which have become quite disconnected from the northern mass through the agency of subsequent erosion, which has removed a vast amount of sedimentary materials over the central portion of the range. The northerly inclination of the Carboniferous deposits carries them beneath the level of the Gros Ventre, along the north side of which appears a line of beautifully-eroded bluffs, showing a thickness of several hun-

dred feet of deep-red arenaceous deposits banded with lighter tints, which extend several miles along the stream, and to the east probably rise up on the mountain flank, where they present the escarpment exposures lapping up on the Carboniferous deposits, as mentioned above. Remnants of these "red beds" may also occur on the northeast flank of Station XLIV ridge between the summit and the debouchure of the Gros Ventre, but, approaching the latter point, they have been swept away, the Carboniferous forming the whole mountain side, and extending even beyond, where they form a narrow belt on the north side of the stream.

The apparent nature and distribution of the formations which succeed and overlie the "red beds" to the north, as made out from this point, will be noticed in a succeeding page relating to the Mount Leidy region. To the south and southwest the view embraces the Silurian-capped heights of the foreland between Stations XLVI and XLIV, and round to the southeast the foreshortened southern flank of the north barrier and the complicated, much-eroded interior portion of the range penetrated by the ramifications of the drainage of the Little Gros Ventre.

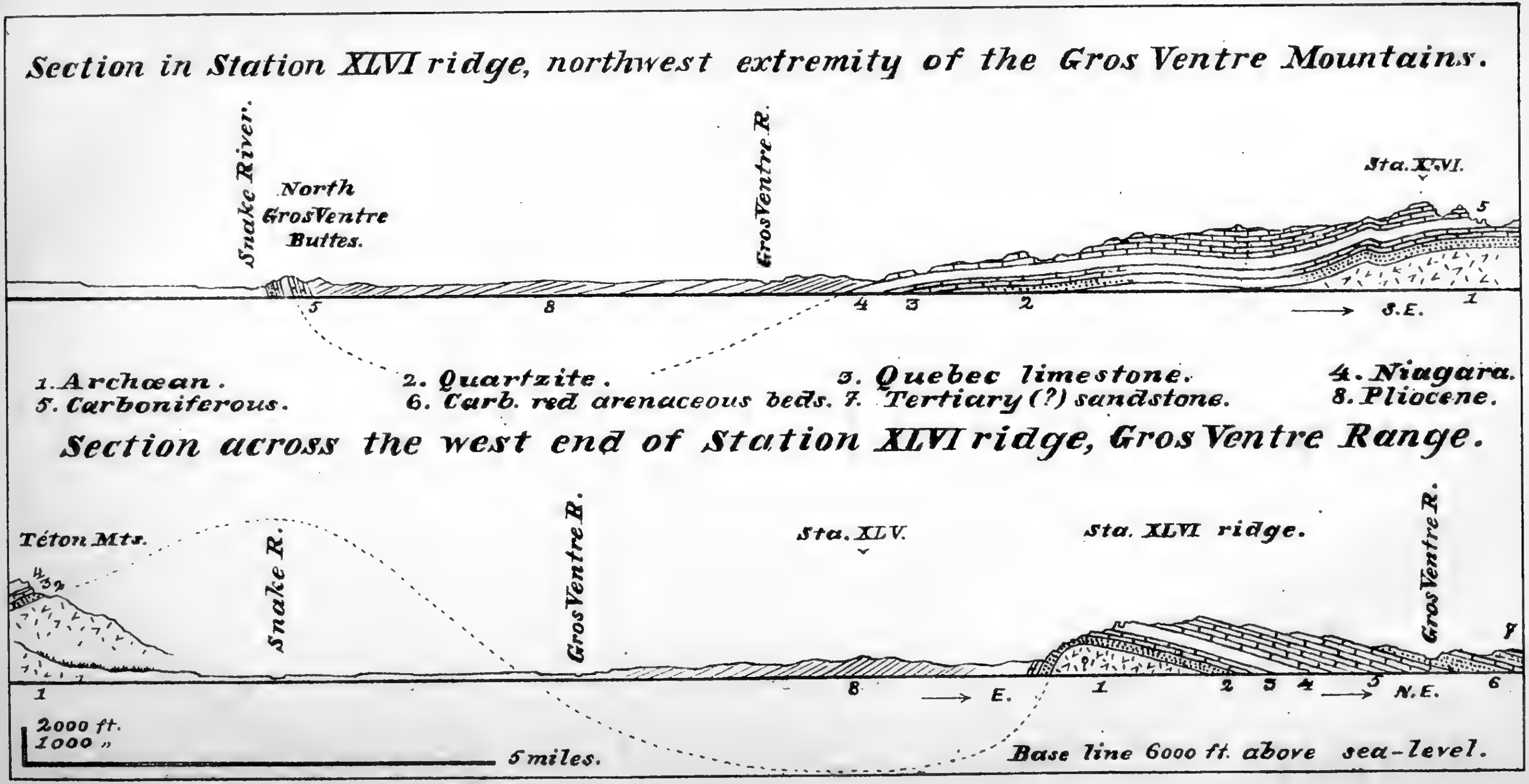
In the opposite or south side of the Little Gros Ventre Valley a tumbled mass of rusty quartzite or quartzitic sandstone was observed, which lower down appears in the broken southern slope of Station XLVI ridge, where it forms a more or less well-defined low ridge, which terminates to the northwestward in the recess at the foot of the mountain about opposite Station XLV. This ridge is very like that on the north side of the cañon descending from Station XLIV, being composed of broken angular fragments of the same hard quartzitic sandstone. In the steep bluffs immediately north of the end of this ridge highly tilted ledges of light-buff, reddish-tinged, laminated sandstones were observed, dipping southwestward at an angle of about 70°. These sandstones, in connection with the apparently overlying quartzitic sandstone, form a heavy deposit, which rises up into an anticlinal fold in Station XLVI ridge, with sharp dips on the southwest, but much more moderate inclination on the northeast flank. The above steeply-tilted sandstones are believed to be Primordial. In this vicinity were observed *débris* exposures of thin-bedded, peculiarly weathered limestone, recalling the Quebec Group beds, and heavy ledges of buff magnesian limestone, holding the position of the Niagara, appear in the neighboring heights. This locality is between two and three miles about south-southeast of the debouchure of Gros Ventre River. The nearly northwest trend of the axis of the fold carries it out into the region of Jackson's Basin to the south of that point, where all these strata have been greatly denuded and covered by depositions of late Tertiary age.

Sections illustrative of the foregoing observations on the geology of this region are given in the accompanying diagrams.

THE MOUNT LEIDY HIGHLANDS.

North of the Gros Ventre Mountains there occurs a rather wide belt of highland and upland plateau, about twelve by twenty miles in extent, which is limited on the south by the Gros Ventre River, on the north by the Buffalo Fork and Black Rock Creek, on the west by Jackson's Basin, and to the east it rises into the continental watershed of which it forms the western flank within the limits designated. This area is traversed nearly centrally by a very irregular low mountain ridge or water-divide, which culminates in two conspicuous summits of nearly equal altitude, to the westernmost of which the Snake River expedition of 1872 gave

PLATE XLI.



Section in Station XLVI ridge, northwest extremity of the Gros Ventre Mountains.
Snake River.
North GrosVentre Buttes.
GrosVentre R.
Sta. XLVI.
5
5
8
4
3
2
S.E.
1
1. Archæan.
2. Quartzite.
3. Quebec limestone.
4. Niagara.
5. Carboniferous.
6. Carb. red arenaceous beds.
7. Tertiary (?) sandstone.
8. Pliocene.
Section across the west end of Station XLVI ridge, Gros Ventre Range.
Téton Mts.
4 3 2
Snake R.
GrosVentre R.
Sta. XLV.
Sta. XLVI ridge.
GrosVentre R.
7
1
8
E.
1
2
3
4
5
N.E.
6
2000 ft.
1000 "
5 miles.
Base line 6000 ft. above sea-level.

the name of Mount Leidy, in honor of the distinguished comparative anatomist, and which may be used to designate the well-defined highland region of which it forms so prominent a topographic feature. For so moderately elevated a region its surface features are exceedingly broken and diversified. The plateau-like uplands are cut by narrow drainage channels, and the higher ridges are carved into the most intricate forms by the erosive action of atmospheric agents. These features offer marked contrast to the massive mountain topography of the region we have just left, and this finds ready explanation in the equally pronounced contrast that subsists in the geological features peculiar to each. The whole region is pretty well covered with forests of pine and fir; indeed, extensive tracts of dense timber are found on the gentler slopes, and equally large areas of burnt forests are grown up with an almost impenetrable growth of young pines. The upland levels are also thickly covered with groves of aspen, interspersed with open grazing-lands. The steeper mountain summits are generally perfectly nude, while the lower ridges show frequent lines of bluffs in which the strata are revealed over almost the entire field. Fortunately this circumstance was greatly in our favor, but for which, indeed, we should have brought away even less satisfactory data than what rewarded the very hasty examinations which we were compelled to bestow upon the region.

We have already seen that the mountain range to the south of this area presents a barrier of uplifted sedimentary formations composed of Palæozoic and in part of Mesozoic strata, which dip northward, the older deposits indeed showing only a limited area of outcrop north of the Gros Ventre River in the vicinity of its debouchure on the border of Jackson's Basin. The Mesozoic formations, however, in the lower course of the Gros Ventre Valley, at least, show their full development in the immediate vicinity of the stream, extending back, northward, where they occupy a narrow belt in the southern flank of the Mount Leidy highlands; but to the eastward they, too, reach southward, and at least the "red beds" are carried high up on the northern flank of the Gros Ventre Range, as has been already observed.

With regard to the nature of the geological formations that occur toward the sources of the Gros Ventre, the observations made by Dr. Hayden, in 1860, have so pertinent a bearing on the subject under present consideration, that the liberty is taken to transcribe in full what he has recorded on the geology of that section of the country. Under date of June 5, he writes:* "We ascended a high ridge, from which we could see to a great distance. Looking to the dividing crest of the Wind River Mountains, we find the exposed belt of granite to be not more than four or five miles in width, and gradually lost in the basaltic or eruptive range, which also renders itself conspicuous. The Tertiary beds seem to reach fully up to the crest on the west side [in the vicinity of Union Pass], and often passing * * * even to the entire divide of the mountains. We also see, high up on the flanks of the mountains, a full series of the more recent Tertiary beds, with pinkish bands, precisely similar to those in the Wind River Valley. These pass up into yellow sandy marls and sandstone. I have estimated the entire thickness of the Tertiary beds on the west side of the mountains at 1,200 to 1,500 feet. In the lignite beds and vicinity are great quantities of selenite and silicified wood. All over the highest hills near the crest of the mountains, 10,000 feet above the sea, are the recent Tertiary beds.

*Exploration of the sources of the Missouri and Yellowstone Rivers, under the direction of Capt. W. F. Reynolds, Topographical Engineers; Geological Report by F. V. Hayden, 1869. Reprint U. S. Geological Survey, 1872, chap. I.

A large portion of the superficial Tertiary strata incline from Wahsatch and Green River Mountains, showing that these deposits were probably disturbed at the same time by the uplifts of these ranges. * * So far as we have yet seen, at least fifty miles of the dividing crest of the mountains [Wind River Range] are covered with Tertiary rocks."

The Tertiary deposits above referred to Dr. Hayden describes in the following terms, under date "June 1.—On the west slope of the Wind River Mountains [vicinity of Union Pass] we meet with a thick deposit of drift materials, which, as we descended to Gros Ventres Fork, soon expanded into a great thickness of recent strata, evidently quite recent Tertiary. * * * I should think that this formation had been deposited after the surface of the country had attained, for the most part, its present configuration. The strata consist of loose, fine arenaceous clays, the layers containing more or less arenaceous matter, which does not effervesce, and layers of harder rock, a fine-grained and coarse sandstone, and sometimes an aggregation of grains of quartz with ferruginous matter and particles of mica. The materials are all evidently derived from the vicinity. Some of the masses of rock present a compact, fine siliceous structure, and effervesce feebly."

Again, under date "June 4.—To-day the Tertiary strata begin to assume a good deal of importance. We have the brick-like materials which result from the burning out of the lignite beds. There were also masses of indurated clay, covered with vegetable remains, and impure lignite beds; indeed, all the indications which the lignite Tertiary beds present on the east side of the mountains. The beds are also much disturbed, inclining at various angles. The following section of the lignite beds was taken here, which will serve to show their resemblance to those on the eastern side of the mountains:

"9. A yellow, fine-grained sandstone and dark-gray limestone with a parting of clay. The limestone is quite brittle, breaking into thin laminæ, and contains impressions of dicotyledonous leaves and a distinct species of *Unio*. 15 feet; inclination, 28°.

"8. Light-yellow sandy marl. 15 feet.

"7. Impure lignite. 4 feet.

"6. A series of marly clays, which, when saturated with water, form a thick paste, variegated in color. Near the summit, just below the lignite, is a thin seam, four to six inches, of hard-shell limestone, with the shells in the most comminuted condition. I recognized *Unios*, *Viviparas*, &c., sufficient to show that the deposit is fresh-water. 150 feet.

"5. Alternate dark-gray and brown-yellow gray, fine sandy and clay layers, with some calcareous matter and a few seams of incoherent sandstone, sometimes assuming a concretionary character. 200 feet.

"4. Impure lignite and clay. 8 inches.

"3. Yellowish-gray clay. 4 feet.

"2. Impure lignite. 6 inches.

"1. Yellowish clay with some calcareous matter."

"The general inclination of these beds is about 20°."

These deposits were traced westward down the valley of the Gros Ventre, where they evidently pass to the north side of the stream, along which Dr. Hayden encountered successively Cretaceous, Jurassic, and the arenaceous "red beds" of the Triassic, as he descended the valley to Jackson's Basin. The lithologic and paleontological characteristics of the latter formations, as described by Dr. Hayden, show them to bear intimate resemblance to the same horizons as developed on the east side of the Wind River Mountains. A section, representing a thickness of between 300 and 400 feet, represents the Cretaceous as made up of

sandy marls, clays, sandstones, and occasional limestone layers, including near the middle several layers of impure lignite. Arenaceous material predominates, and the lower hundred feet has a gray ashy color.

Overlooking a large part of the southern slope of the Mount Leidy highlands, from Station XLVI on the south side of the Gros Ventre Valley, it is found to be traversed by three parallel belts, which comprise so many rather conspicuous lithological zones parallel to the longer axis of the highlands. The first belt or zone is composed of the deep-red arenaceous deposits, banded with paler-colored layers, characteristic of the "red beds" or Triassic. These deposits present their edges to view in a line of beautifully-eroded bluffs on the north side of the Gros Ventre, the strata dipping gently northward. Beyond the "red beds," north, the slope is broken by long, low ridges, in the southern face of which light-drab deposits appear, composed apparently of shales and arenaceous beds, with perhaps calcareous indurated bands, and a heaver mass of brown-drab firmer material above, reaching a thickness of several hundred feet. The latter deposits form a belt at the foot of the steeper ascent culminating in Mount Leidy, and stretching to the southeast, or east-southeast, where they occur in quite prominent ridges, cut across by a tributary which rises in the hills beyond. Farther on in the same direction they do not appear so strongly marked, and soon pass from view behind a near shoulder on the northern flank of the Gros Ventre Range. These beds seem to dip gently to the northeast, the line of peculiarly regular escarped ridges in which they outcrop gradually rising to the northwestward, where, however, as in the opposite direction, they soon cease to form so prominent and well-defined topographic and geological features as seen at this distance.

In the intervening nearer slope such exposures of the component strata as appear seem to indicate a more disturbed belt, in which the beds are sharply folded along a line apparently parallel with the general trend of the Gros Ventre uplift. More than this was not clearly indicated. These deposits are doubtless the same as those described by Dr. Hayden in the immediate vicinity of the Gros Ventre. The disturbed or folded belt may include the later Mesozoic formations, but the higher and wider belt is probably wholly composed of Tertiary deposits, including the superior lignitic series of the region.

To the north of the drab belt the hills are less regular in outline, are more eroded into sharp, buttressed ridges and deep gullies, dotted with trees and patches of undergrowth. These hills appear to be composed entirely of the brownish ash-colored deposits above and lighter ash or drab beds with comparatively thin beds of yellowish-buff sandstone below. They form a heavy deposit a thousand feet or more in thickness in the cluster of hills around Mount Leidy. So far as could be determined, these strata uniformly incline at a moderate angle northwards, and such undoubtedly appears to be their dip in the northern slope of the highlands.

The foot-hills along the western side of this highland region are covered with a fine brown soil, with scarcely any coarse material visible in their surfaces; their higher slopes generally covered with pine forests and undergrowth. A few miles north of the Gros Ventre the foot-hills terminate more abruptly on the terraced plain of the basin. Obscure exposures of light or white fragmentary limestone were here met with, which, from the similarity in color and texture, was taken to be identical with the thin-bedded limestone occurring in the late Tertiary deposits in the vicinity of Station XLV. Similiar patches of limestone *debris*

occasionally appear in the surface of the outlying terrace, as has already been mentioned.

In the point south of the Elkhorn white arenaceous deposits outcrop in the hill-side at an elevation of 400 or 500 feet above the stream. In the steep northern face of this ridge the same beds rise gradually to the east, or rather southeast, and in the broken wooded ridges that intervene between Mount Leidy and Jackson's Basin exposures of brownish-colored deposits show here and there, and which apparently underlie the before-mentioned beds. The lower slopes of these hills bordering the valley of the Elkhorn are buried under accumulations of water-worn pebbles, which make up considerable ridges and are spread over all the lower portions of the plateau between the Elkhorn and Buffalo Fork, the little basin into which the former stream opens showing some fine examples of terracing in these deposits. These loose materials are chiefly composed of quartzite bowlders and pebbles beautifully rounded and polished.

Ascending the valley of the Elkhorn, a few miles above the Snake bottoms its valley closes up in a narrow gorge, in which an exposure of a couple of hundred feet of strata was seen. The section shows 75 to 125 feet of fine arenaceous clays, banded in thin layers of light and dark drab color, with rusty-buff indurated arenaceous layers and soft concretionary sandstone above, and containing two thin seams of lignite, one above and one below, the strata inclining northward at angles of from 12° to 20°. The drab clays are unconformably overlaid by a variable thickness of yellow gravelly earth which looks like a Post-Tertiary deposit, and so was mentioned in a preceding page, which makes up the remaining height of the bluffs. Curious funnel-like sinks were noticed in the drab deposits, the origin of which is not clear; they have the appearance of having been caused by the undermining of the superincumbent layers, which gave way on all sides, curving into and filling the excavations. There was no indication of the burning out of coal seams, by which this effect might be produced.

The extremely broken foot-hills on the northern declivity of Mount Leidy, descending to the Elkhorn, exhibit yellowish-buff sandstones and light-buff to white indurated beds, which gently rise up and form the basis of the peak. The latter, as also its principal spurs, is composed of light-brownish or ash-colored deposits, and toward the summit, in the northwest face, appear several brownish harder ledges. The brownish deposits, at a distance, have the appearance of homogeneous fine arenaceous clays, but which, it is suspected, may prove to be identical with a remarkable conglomerate deposit occurring north of Buffalo Fork, hereafter to be noticed. As has before been mentioned, these deposits also occur in the high ridge a few miles to the east or southeast of Mount Leidy, and in the continuation of the same heights, as they approach the watershed, lightbuff earthy or arenaceous deposits are associated with the ash-colored beds. As seen from Station XLVIII, on the north side of Buffalo Fork, the whole northern flank of this highland region is brought into view, affording an opportunity of studying its general topographic and geological features. The brownish ash-colored deposits are persistent stratigraphic features throughout the culminating crests, presenting, in their style of weathering, a strikingly peculiar appearance. This is well displayed in the view of Mount Leidy from the latter station. The mountain, although quite isolated, spreads over a considerable space, throwing out sharp, partially wooded, and beautifully sculptured spurs, differing from anything hitherto observed in the district, though it is repeated in similar and probably identical deposits in

the region to the north, to be noticed presently. The long undulating slopes descending from the watershed south of Black Rock Creek reveal light-buff arenaceous deposits wherever the surface is broken by the bluffs and not concealed by forests, which latter thickly cover the more elevated portions. In the bluffs along the narrow valley of the Blackfoot appear frequent exposures of light-drab clay and soft buff-gray sandstones, which weather in shelving surfaces, and in the promontory point at the confluence of the Buffalo Fork buff sandstone ledges outcrop, dipping gently northeastward.

In the low aspen-covered upland intervening between the Elkhorn and Buffalo Fork a fair section of these strata may be seen. This belt presents a succession of south-facing low bluffs, with long gentle slopes to the northward, a conformation of surface determined by the character and position of the subjacent rock strata, which uniformly dip in the direction of the gentle declivities. In the lower extension of the bluffs north of the Elkhorn, light-brown earth, with indurated layers, appears in the steep slope, which is strewn with the water-worn pebbles and bowlders that enter largely into the composition of the unconsolidated superficial deposits in this region. Higher up the valley to the east the bluffs are composed of rusty and light buff soft sandstone, bedded in light-drab, clayey material, dipping northeastward at angles of from 10° to 15°. In the next ridge, less than a mile north, occur rusty-buff, shaly, and concretionary sandstones, interbedded with softer deposits which weather into a fine light-brown soil. North of the last, a similar ridge shows a ledge of light-buff sandstone associated with thin irregular layers of rusty ferruginous sandstone; and in a still higher bluff, the northern slope of which descends to Buffalo Fork, a heavy bed of soft, light-buff sandstone, with rusty and buff indurated layers, appears in the upper third of the abrupt acclivity, forming an exposed thickness of 50 to 100 feet, associated with drab and brown earthy deposits, the disintegration of which produces a light-drab loamy soil. The latter sandstone resembles the ledge occurring in the base of the cone of Mount Leidy. The light sandstones outcrop in the ravines intersecting the aspen ridges 400 to 500 feet above the Elkhorn. Patches of "alkali" soil were here met with, which, together with the excellent pasturage, may account for this locality being a favorite resort of elk and deer, the abundance of whose antlers scattered over these uplands suggested the name of the above-mentioned stream. The higher upland slopes also are strewn with more or less drift material, consisting of thoroughly-rounded quartzite and gneiss bowlders and occasional fragments of basalt.

The exposures above alluded to are represented in an accompanying diagram, in which an attempt is made to show their probable relations to the deposits occurring in the mountain borders on the north and south.

BUFFALO FORK AND SNAKE RIVER DIVIDE.

The lower course of the Buffalo Fork winds through a beautiful valley for the distance of about eight miles, when it expands into the Snake bottoms, east of the outlet of Jackson's Lake. The valley is occupied by low terraces, and rather wide alluvial bottoms, with extensive tracts of wet meadow-land, interspersed with thickets of willows. Along the north side the hills are bolder than the south-side upland border, and are well wooded with pines and spruces, and at many points in the somewhat broken declivity limited exposures of their component strata appear.

Below the mouth of Black Rock Creek a line of highish bluffs borders the right bank of the river for a short distance, in which a thickness of

400 to 500 feet of strata is exposed above the water-level, showing the basis rocks of the adjacent hills. A section at this locality is given below, the thicknesses of the beds estimated.

Section in bluffs on Buffalo Fork, foot of Station XLVIII.

1. Buff-drab clays, indurated arenaceous and argillaceous layers below, 60 feet.
2. Buff sandstone, exposed 2 feet.
3. Buff and ash-colored clays, darker drab below, 70 feet.
4. Buff sandstone, exposed 2 feet.
5. Slope, with indications of buff-drab clays, 65 feet.
6. Dirty buff sandstone, exposed 5 feet.
7. Light drab clays, 60 feet.
8. Dirty buff sandstone, exposed 4 feet.
9. Space, with drab clays, 40 feet.
10. Rusty brownish sandstone, exposed 3 feet.
11. Space rising into crest of ridge, probably ash-colored clays, 100 feet or more.

The edges of the strata in the above exposure appear nearly horizontal, or slightly inclining upstream; but the dip is to the northeastward at an angle of from 10° to 15°. There are no indications of lignite seams at this place, although the beds belong to the Tertiary series on the south, noticed in a preceding page. A hasty search in the beds at this locality failed to discover the vestige of organic remains; but at a point some distance above in the foot of the same line of bluffs, indurated bluish-drab argillaceous layers, probably belonging to the horizon of No. 1, afforded one or two varieties of dicotyledonous leaves.

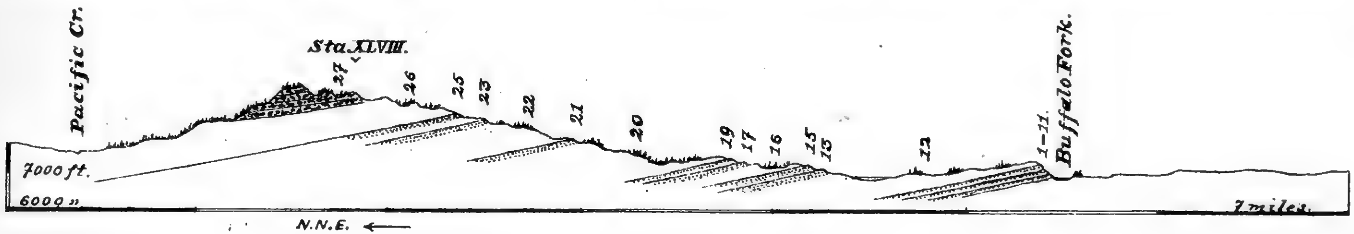
From the crest of the river bluff the surface slopes into a parallel drainage depression, connected with the hills to the north by a saddle flat, in which a grass-fringed pond was found, its outlet dammed by the work of beavers. The opposite slope rises in successive steep ascents and high terrace platforms into the summit of a cluster of wooded hills in the Buffalo Fork and Pacific Creek divide, on one of the outer knobs of which Station XLVIII was located at a height of about 2,000 feet above the former stream. The rock exposures observed in the southern slope of the mountain, where they are much hidden by *débris* and undergrowth, present the following section of superimposed strata in continuation of the bluff exposure.

Section in south slope of Station XLVIII.

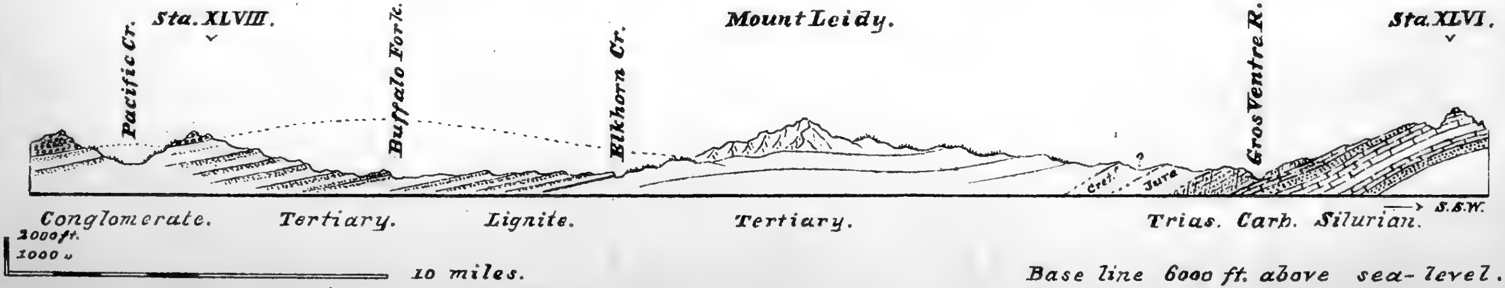
12. Space between foot of main slope and outlying river-bluff.
13. Thin bed of buff-gray sandstone in foot of declivity opposite pond, about 250 feet above river-level.
14. Unexposed space.
15. Buff-gray, shaly sandstone, 2 feet exposed, at elevation of about 360 feet above the river.
16. Slope, unexposed, covered with gneissic and other water-worn bowlders.
17. Thin-bedded, buff sandstone, exposed 5 feet, elevation 450 feet.
18. Unexposed slope.
19. Buff-gray sandstone, obscure exposure, elevation about 540 feet.
20. Broken slope about three-quarters of a mile across, thickly wooded in part, and covered with drift materials of all sorts, with traces of brown earth in open, sage-grown spaces.

PLATE XLII.

Section in south slope of Station XLVIII, north side of Buffalo Fork.



Section across the Mount Leidy Highlands, between Stations XLVIII and XLVI.



21. Gray-buff sandstone, in places thin-bedded, imperfectly exposed, probably a heavy bed, elevation about 1,000 feet above the river.
22. High bench, strewn with water-worn gravel and bowlders of all sorts of rock, elevation 1,200 to 1,300 feet.
23. Heavy-bedded buff sandstone, 25 feet exposed; dip, 10° to 15°, northeastward. Elevation about 1,500 feet.
24. Slope, covered with drift materials.
25. Brown and buff shaly sandstone, elevation 1,660 feet.
26. Brownish drab clay and drift-covered slope.
27. Heavy conglomerate deposit crowning the divide, and eroded into knobs. This deposit is made up almost entirely of thoroughly water-worn pebbles and small bowlders of white to red quartz and quartzose rock, gneiss and granite being sparsely represented. A brownish, indurated, arenaceous material forms the paste or cementing medium holding the cobble-stones, which latter are weathered out in immense quantities in the slopes.

There can be no question as to the epochal identity of the sandstones and ashy or drab clays shown in the above section with the deposits occurring in the upland south of Buffalo Fork. But no clew as to the age of the heavy mass of water-worn bowlders and pebbles crowning the heights in the vicinity of Station XLVIII was obtained. The latter deposits, it seems, prevail over a considerable area of this high water-divide, extending over to the region about the sources of the Snake, a few miles to the north, where Professor Bradley mentions their occurrence in the following terms: "Ascending the high, sharp ridge on the west side of this valley [the Snake rises in a "flat valley-divide"], at least 500 feet high, we find its slopes to consist entirely of large and small well-rounded pebbles of variously-colored quartzites up to the very summit, where this deposit is just pierced by an outcrop of the gray trachytic lavas and red basalt, partly vesicular, though mostly compact, which form the nucleus of the ridge. We here stood upon one of the highest points in that neighborhood, about 8,654 feet [9,609 feet, subsequent determination recorded on Professor Bradley's geological map] above the sea; so that we were entirely at a loss as to the source from which had flowed the large river which had distributed such immense amounts of gravel and sand. The deposit is evidently very ancient, but no considerable consolidation had taken place." * * * "Passing westward the quartzite-gravel continues for several miles, though the mass of all the ridges is composed of a coarse volcanic breccia."

The inclination of the conglomerate in the vicinity of Station XLVIII could not be satisfactorily determined. The crest of the ridge, which extends in a north-south course about a mile, perhaps more, is eroded into knobs strewn with cobble-stones, and studded with dwarf, storm-rent pines, firs, and cedars. It presents in these respects a feature entirely unique in our experience in this region, recalling late Post-Tertiary accumulations found in other regions; indeed, the loose materials are physically identical with those forming the terraces and occurring in the beds of all the streams flowing into Jackson's Basin from this quarter. The west side of the ridge falls steeply into a deep valley, the slopes densely wooded, and showing here and there slides, at the foot of which the cobble-stones are piled in great heaps. This valley apparently flows out into that to which the name Big Bend Creek was applied by the Snake River expedition of 1872, and its sources are the same as the stream to which Captain Jones, the following year, gave the name Pa-

cific Creek. Its bed here is occupied by a narrow flat in which the stream is ponded by beaver-dams.

Station XLVIII gives a good view of the surrounding country, from which much important information may be gained relative to the general character and distribution of the geological formations occurring therein. Looking westward, the southern declivity of the mountainous divide north of Buffalo Fork and Pacific Creek is traced to the angle where the hills trend round to form the eastern boundary of Jackson's Basin opposite and north of the lake. At the point where the slopes pass round out of sight a pair of small lakes lie within the higher and older terrace area at the foot of the mountain, which Professor Bradley describes as bayous of the ancient abandoned channel of the Snake. Beyond lie the glistening waters of Jackson's Lake, and the majestic wall of the Téton Range seems close at hand, though really more than 15 miles away. This southern slope of the divide, probably in the vicinity of the twin lakes, shows a low outlying hill made up of a brown earthy (?) deposit which is weathered very like deposits of similar appearance occurring in Mount Leidy and the high hills to the east. Between the latter locality and the high river bluff near the upper end of the lower valley of Buffalo Fork described above, in the recess formed by the entrance of the valley of Pacific Creek, the hills are low and show exposures of buff-yellow sandstones like those in the river bluff above. These sandstones are often gray and generally coarse-grained, recalling Laramie Group deposits in the Snake River and Caribou Ranges, although they are doubtless more recent. The exposures of "gray and buff, fine-grained, shaly sandstones" described by Professor Bradley, as mentioned in a preceding page, that outcrops near the mouth of Buffalo Fork, probably belong to the same series. Professor Bradley also mentions in the adjacent slopes the occurrence of "partially-cemented Post-Tertiary sands and gravels, with occasional exposures of white marly clays, supposed to be of the same age, though no fossils were seen." The latter deposits are clearly, in part at least, identical with before-mentioned strata occurring in the vicinity of the Upper and Lower Gros Ventre Buttes, but the gravel beds would hardly be referred to the deposits which make up the bulk of the hills north and south of the lower course of Buffalo Fork, though they may belong to the singular conglomerate whose appearance has already been mentioned in the summit of Station XLVIII. The disturbed condition of the sandstones at the mouth of Buffalo Fork contrasts with the uniformly moderate and apparently regular inclination of the soft sandstones occurring in the adjacent hills either side of the Buffalo Fork, with which, however, they offer close agreement lithologically.

To the northwestward of Station XLVIII, the slopes in the opposite side of Pacific Creek rise into a high, short mountain ridge, perhaps three or four miles distant, forming a prominent landmark, which we had had in view since entering Jackson's Basin. Its southern face presents escarped walls sustained by bulky buttresses in which the bared strata are intricately sculptured by the elements. These apparently consist of a heavy conglomeritic deposit, in appearance laminated or thin-bedded, rusty yellow-buff and drab, with indurated arenaceous bands, reaching a thickness of 500 feet or more, which rest upon a heavy bed of light-buff arenaceous rock, probably soft sandstone, showing an exposed thickness of 50 to 100 feet above the steep talus. The inclination is gently northeastward. The outlying foot-hills on the south are much cut up by the wash, and are well wooded, showing only now and then exposures of buff arenaceous deposits, until approaching the bluffs on the north

side of the stream, in which a thickness of a couple of hundred feet of yellowish and drab arenaceous clays and sandstones outcrop, passing under the above deposits, and which belong to the series included in the section in the outlying slopes south of Station XLVIII. The general similarity of the heavy drab deposits in the crest of the ridge with those in Mount Leidy, strongly suggests their probable stratigraphic identity, and to which belongs the remnant capping Station XLVIII.

To the left of the above mountain is seen another high, massive summit forming the divide a few miles to the west, the eastern face of which is broken down in cliffs of dark, rusty-weathered strata inclining gently west or southwestward, the nature of which could not be satisfactorily made out at this distance. From the low Tertiary uplands south of Buffalo Fork the southern aspect of the latter mountain is rounded, displaying brownish, earthy-looking deposits. From this point of view the mountain is seen to form one of the heights of the divide, in a depression of which between this and the first-mentioned ridge appear more distant mountain-crests to the north, bearing reddish-brown ledges, and which may belong to the volcanic-crowned ridges found by Professor Bradley on the northern edge of this divide at the head of Coulter's Creek. In the latter quarter he observed the prevalence of "gray trachytic lavas and red basalt" and "rapidly-disintegrating volcanic rocks, mostly conglomerates of trachytic porphyry, obsidian, &c.," the latter evidently belonging to the volcanic series which is so largely developed in the watershed farther east. Light-grayish deposits, probably sandstones, are exposed in the summits of the more massive and mountainous portion of the divide still to the west, where their outcropping edges, facing the south, are nearly horizontal. Farther on, the mountain-crest shows similar light-grayish strata inclined gently in the direction of Jackson's Basin, and just beyond they again rise to the westward, forming a shallow synclinal in the vicinity of the elevated summit which marks the angle at the point where the divide trends round more to the north.

Throughout this portion of the divide there are no evidences of great disturbance, the dips apparently not exceeding 15°, and generally much less. But farther north, where the ridge sinks beneath the volcanic plateau of the lake region in its northwestern flank, opposite the confluence of Lake Fork and the Snake, the sedimentary deposits rise at a steep angle to the northwest, bringing to view a belt of Palæozoic in the foot of the mountain. The latter is described by Professor Bradley, from observations made by Mr. Taggart, as follows:* "At the base lie about 200 feet of white and light-gray quartzites, overlaid by from 500 to 600 feet of light-drab and dark-gray limestones, and about 100 feet of gray sandstones, followed by heavy beds of red, shaly sandstones, apparently the same as those seen higher up the river. I am not satisfied as to the age of either the limestone or the quartzite" [colored on the map accompanying the report, Quebec and Potsdam]. "The ridge is capped by beds of porphyritic trachytes, having a dip of about 30° to the southeast, while the limestones beneath dip about 40° in the same direction, showing that their tilting commenced before the deposition of the trachytes." About seven miles above the mouth of Lake Fork, Professor Bradley notes the occurrence of "red, shaly sandstones, containing no fossils beyond indistinct fucoidal markings, which are referred with doubt to the Triassic period. The gray beds of the lower part of the series make their appearance in the lower end of the cañon." These de-

* U. S. Geol. Survey of the Territories, 1872, p. 259.

posits are represented as forming a belt a mile in width where they cross the Snake, rising above the basaltic flow which here fills the valley.

To the south and east of the latter locality Professor Bradley found a wide area of country occupied by the volcanic deposits, on the one hand reaching up to the crest of the dividing ridge, and on the other extending over into the Elk Ridge between the Snake and Barlow's Fork. In the valley and slopes of the latter stream, towards its head, a considerable patch of Tertiary was met with, to which Professor Bradley alludes: "About two miles below the falls we began to find outcrops of a fine-grained, ferruginous, laminated sandstone, destitute of fossils, but probably of Tertiary age. Some of the layers showed abundant ripple-marks. At the falls the rock is heavy-bedded. The dips are mostly about 22°, varying somewhat on either side of due east. Just above the falls, and opposite to our camp, four thin layers of coal, varying from one inch to six inches in thickness, and two layers of clay ironstone (iron carbonate), varying from six inches to one foot in thickness, are all included within ten feet of shales. * * * The upper slopes of the ridge on either side [of the valley-basin] are mostly bare of timber, and many parts of them are badly washed. Those on the east are composed of mostly thin-bedded sandstones, probably of Tertiary age, at least 2,000 feet thick, with variable southeasterly dips. A few red layers appear, but the majority of them are gray. No fossils were found, though careful search was made for them."

The eastern face of Station XLVIII ridge abruptly falls to the level of a high sloping plateau occupying the interval between this point and the high mountain north of Buffalo Fork Peak. This plateau falls in a succession of uneven benches to the lower cañoned course of Buffalo Fork, its surface covered with grassy slopes interspersed with conifers and groves of aspen. The contour and occasional exposures of light-buff deposits denote the Tertiary character of this slope, which reaches up to the divide between Buffalo Fork and Pacific Creek, and doubtless once extended over to the northward, connecting with the Tertiary deposits in the upper basin of Barlow's Fork. Along the northern foot of this slope, in the lower cañon of Buffalo Fork, nearly continuous exposures of light-buff arenaceous beds appear, extending several miles to the east until arrested by the massive mountain barrier which forms the portals to the upper or mountain course of this stream. These deposits are mentioned by Professor Bradley, from notes communicated by Mr. Bechler, as follows: "About 12 miles up, the valley narrows to a cañon from 350 to 400 feet deep by from 50 to 200 feet wide, for about three miles, with coarse gray sandstone walls. About one and a half miles of a rounded basin, with beaver-dams, then intervenes before reaching the second cañon, which has nearly the same character as the first and is about two miles long. A broad basin succeeds, from five to seven miles across, reaching up to the foot of the high vertical limestone walls, * * * whose rugged crest shows plainly from the mouth of the valley."

Light-colored deposits resembling the above Tertiary beds reach well up on the flanks of this mountain barrier on either side of the gorge through which flows the Buffalo Fork, where they rest apparently unconformably upon earlier Mesozoic formations and possibly the Carboniferous. They do not appear to be present far within the entrance to the gorge, although Professor Comstock notes the occurrence of similar beds higher up to the north-northeast, in the divide between Lava Creek and the upper course of Pacific Creek, where they dip southwest at an angle of 57°, "and in the cañon of Buffalo Fork, just below Camp 56,

similar beds with additional members are found dipping in the opposite direction 89°. Between these points no Cretaceous exposures were noticed, but judging from the dips of the lower sedimentary strata, which were observed on Lava Creek between Camps 55 and 56, there must be one or more folds intervening."* Also reference is made to "the coal-bearing series on Buffalo Fork. The strata containing the coal are nearly vertical and in folds, so that the beds are several times exposed in the cañon within a short distance. Much of the coal is very good."† Professor Comstock regarded all these strata as of Cretaceous age. From the above observations it would appear that these deposits had been greatly disturbed by elevatory forces seated in the Buffalo Fork Mountain, which refers this uplift to a late date. Other stratigrapical appearances observed in the northwest flank of this mountain group will be noticed farther on.

Sufficient has been observed to show that the bulk of the divide between the Buffalo Fork and the drainage flowing north into the upper course of the Snake is made up of the soft arenaceous clays and sandstones of this lignite-bearing series of probable Tertiary age. Professor Comstock is not quite sure as to their stratigraphical identity, but from lithologic resemblances and the presence of coal, he was induced to refer them to horizons in the Wind River region which he determined possess close affinities with the Cretaceous. These deposits, which attain a great thickness, probably above 3,000 feet, apparently occupy an extensive basin whose limits, so far as they have been traced, are defined by the Téton Range on the west, the Gros Ventre Range on the south, and on the north their present limits correspond with the uplifted Palæozoic belt in the vicinity of the confluence of Lake Fork and the Snake, which appears to be the remnant of the southeast flank of a great fold, the crest of which has suffered almost complete demolition by denuding agencies, and was finally buried beneath a vast accumulation of volcanic materials in the region of the plateau of the Continental water-shed. To the northeast they pass beneath the volcanics which, according to Professor Comstock, compose the crests of the Shoshone Range and an extensive mountainous region to the east at the sources of Gray Bull and Stinking Water Rivers, and which, to the west, as seen from Station XLVIII, constitute the elevated watershed ridge, in which great escarpments of the peculiarly banded gray and sombre volcanics appear, dipping slightly northeastward, and eroded into broad-based peaks and lofty promontories.

In the midst of this basin rises the apparently isolated cluster of mountains which culminates in Buffalo Fork Peak. This group seems to be quite disconnected from the surrounding mountain ranges, forming a great dome-shaped mass, the upheaval of which has brought to view the metamorphic nucleus, several hundred feet of which are revealed in the rugged walls of the cañon of Buffalo Fork. But to the east of this group the connection of the Tertiary deposits with similar beds at the head of Wind River Valley is lost beneath the southern extension of the before-mentioned volcanics in the neighborhood of Togwotee Pass; to the south of which, however, they reappear in the ridges of the Mount Leidy highlands which sweep up on and in places even crown the summit of the watershed between the Togwotee and Warm Water or Union Passes, as was inferred by Dr. Hayden.

*Report upon the Reconnaissance of Northwestern Wyoming, under Capt. Wm. A. Jones, Engineers U. S. A., 1873; Geological Report by Prof. Theo. B. Comstock, p. 120.
†*Ib.*, p. 152.

BUFFALO FORK MOUNTAINS.

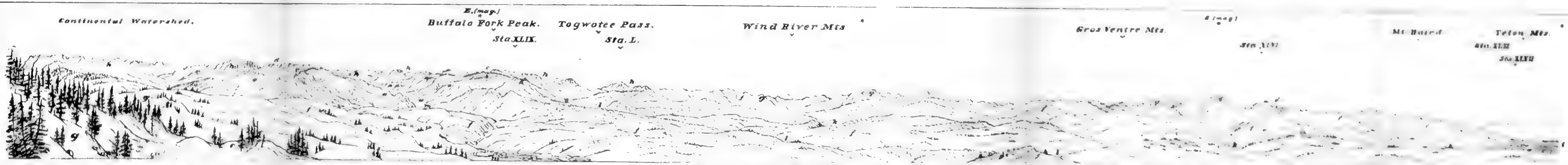
The general stratigraphical features of the Buffalo Fork uplift are brought out most clearly from Station XLVIII, and the observations made from the latter point, supplemented by actual examinations in the southern half of the great dome and the views presented therefrom, afford a comprehensive understanding of its geological structure. Our route of approach led over the slopes between Buffalo Fork and Black Rock Creek, in which, as before mentioned, the Tertiary deposits constitute the subjacent rock strata, the surface, however, being pretty generally enveloped in a coating of drift-like materials, intermingled with which are pebbles of chalcedony and fragments of fossil wood.

On reaching the elevated open valley-basin on the upper course of Black Rock Creek, craggy outliers of volcanic breccia-conglomerate are met with, which a little higher up form a low barrier across which the stream has cut a miniature cañon. These ledges consist of a dark paste holding angular fragments of dark basaltic and drab trachytic lavas, showing in the mass what appears to be a bedded structure, dipping at an angle of 40° about west-southwest. The thickness of the deposit at this locality was estimated at above 500 feet. Overlying the breccia in the crests of the low ridges occurs a peculiar deposit formed of water-worn pebbles and bowlders of quartz and various volcanic rocks held in a fine light drab paste, possibly of volcanic origin. The latter was found in irregular masses, but not revealing their relations to the bedded breccias. The bed of the stream and the adjacent morain-like undulating open slopes below are strewn with drift materials, amongst which occur water-worn fragments of rusty-buff and red sandstone, Quebec and Carboniferous limestone *débris*, which was derived from the adjacent mountains. Just below these open ridges, in the west side of a little stream flowing into Buffalo Fork, the surface is broken by the outcrop of a heavy ledge of hard, reddish-buff and gray, laminated sandstone, standing nearly vertical, the strike about N. N. E. and S. S. W. Less than a mile below the breccia barrier, in the south bank of Black Rock Creek, deep-red shales and sandstones appear, showing a thickness of 100 feet, more or less, dipping southwestward. These deposits doubtless hold the position of the "red beds" of the Trias, and will form the initial point of the section reaching up into the summit of the mountain to the north, on which Station XLIX was established.

Station XLIX occupies a low but commanding peak about two miles west of the main summit of Buffalo Fork Peak, overlooking the cañon of Buffalo Fork and a large extent of its mountain valley to the northeast. The southwest and southern slopes of the mountain are very abrupt and plated with heavy deposits of hard reddish-buff and gray laminated sandstones, almost a quartzite, which occurs in immense slides of *débris* on the lower slopes. Higher up the mountain-side these are seen to be underlaid by heavy beds of gray, drab, and buff, cherty limestones and brownish-drab magnesian limestones, which reach up into the crest at the station. The limestones are charged with characteristic Carboniferous fossils, amongst them a medium-sized *Orthoceras*. The angle and direction of their inclination is very variable, gradually steepening lower on the southwest flank of the mountain, where they dip at one point 65° to 75°, W. 25° S., while in the summit the dip is 35° to 40°, W. to W. 25° S. The brownish-drab magnesian limestone near the summit is very like similar ledges in the debouchure of the Gross Ventre River. On the southwest flank of the mountain, within 300 feet of the summit, basaltic and trachytic erratics were met with.

Plate XLIII.

…ite. h. Volcanic breccia-congl.
i. Jackson's Basin.



a. Archæan. b. Quartzite. c. Quebec. d. Carboniferous. e. Mesozoic. f. Tertiary, with lignite. g. Tertiary conglomerate. h. Volcanic breccia-congl.

n. Buffalo Fork-Pacific Creek Divide. m. Buffalo Fork. l. Black Rock Creek. k. Elkhorn Creek. i. Jackson's Basin.

Buffalo Fork and Mount Leidy Highlands from Station XLVIII.

The northern or northeast face of the mountain breaks down in mural cliffs and steep inclines into the large amphitheatre, whose undulating *débris*-covered surface steeply slopes to the Buffalo Fork. The upper 200 feet or so of the strata exposed in this wall consists of gray limestone, the lower part tinged with red, underlaid by an exposed thickness of about 60 feet of shaly or thin-bedded, fragmentary, drab, buff-mottled limestone, charged with Trilobites and other Lower Silurian fossils, probably of the age of the Quebec Group. The lower and upper limestones grade one into the other without apparent non-conformity or the intervention of clayey beds of passage, although the paleontological transition is sharply interrupted and well defined. If the Niagara is present at all, it here attains meagre development and was not recognized by its fossils. The last-mentioned limestone rests upon a heavy deposit composed of bluish-drab shales, with brown-gray shaly sandstone layers containing a small Orbiculoid brachiopod in great abundance. This deposit may reach a thickness of 100 feet, though its exact vertical extent was difficult to determine.

At the eastern foot of the steep descent of the station commences a broad ridge gradually rising to the eastward into the summit of Buffalo Fork Peak, and which forms the southern wall of the amphitheatre. Its crest is loaded with the shales last mentioned above, broadly rounded and gradually steepening on the south-side slope, while the opposite side steeply descends to the brow of the inferior limestone, which forms a low precipice or wall of bluish and dark-drab, rough-weathered, thin-bedded, brecciated limestone, dirty yellow below, 50 to 75 feet high. This bed determines the form of the connecting ridge, although it does not quite reach the summit of the main peak, which is capped by a flat, bald dome, showing a thickness of 75 feet or more of the inferior portion of the overlying shales. The latter here show yellow sandy micaceous clay, interlaminated with indurated shaly arenaceous layers charged with the little Orbiculoid shell, and thin plates of dirty drab limestone containing fragmentary remains of Trilobites and covered with peculiar branching bodies weathered in relief, which, though apparently structureless, resemble certain ramose forms of *Chætetes*.

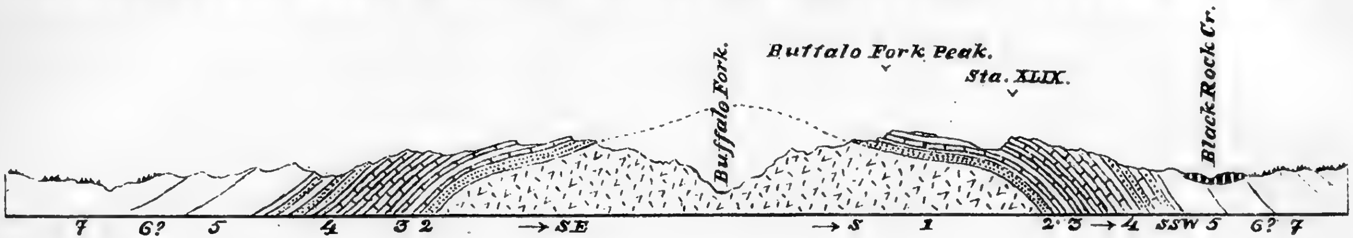
A bold spur puts out from the northern side of the peak, its foot terminating in a much lower but rugged point overlooking the cañon of Buffalo Fork, the peculiar rough, jagged style of weathering and the rusty-brownish sombre hue of the rock of which it is composed determining its metamorphic crystalline character. It is much contorted, and reaches a height of 800 feet or more above the stream. The lower limestone runs out in the spur a short distance, its lower layers of a dirty brown-gray and yellowish-stained color, which, near the extreme point of the exposure, shows a dip S. 30° W. at an angle of 48°. It is underlaid by yellow shales, which rest upon a heavy bed of dark brownish-red and light-gray laminated quartzite, with conglomerate layers. This deposit exhibits an exposed thickness of 50 to 100 feet, and flattens out toward the north, where, in the terminal bench of its outcrop, the dip is about 10°, W. 5° N. The base of the ledge is concealed by the steep talus of *débris*. The east and northeast face of Buffalo Fork Peak also breaks down in precipices of Quebec limestone and the quartzite. High up on the southeast flank of the mountain reclines a huge mass of steeply inclined strata composed of the Upper Quebec limestone and the buff-gray rusty reddish-stained Carboniferous limestone, which form a heavy plating facing the valley of Black Rock Creek. This mass of tilted strata forms a rather conspicuous feature of the mountain, both as seen from below as also from the neighborhood of Togwotee Pass.

Buffalo Fork Peak, which reaches an altitude of 10,200 feet, approximately, above the sea, offers an extensive view of the surrounding country, and the isolation of the great dome-shaped uplift of which it is the culmination, is most clearly brought out. To the north, beyond the deep gorge traversed by Buffalo Fork in its passage across this mountain uplift, the corresponding northern half of the mass shows as a great half-dome, over the summit of which the Quebec Group limestones are curved from west to east. In the central portion of the uplift the Archæan nucleus forms a lofty bench, in whose rugged cañon-face the gneissose rocks present precipitous exposures several hundred feet in height. On either flank reclines the Carboniferous, the inferior red-stained beds forming a marked and easily traced horizon. The latter deposits slope quite regularly, with a moderate inclination on the eastern side, where they are seen on either side of the broad mountain basin, gradually descending, and forming with the Quebec limestones lines of low mural exposures. These extend a considerable distance up the valley of both the main stream to the eastward and that of Lava Creek to the northeast, above which the slopes are broken and do not reveal satisfactory exposures at this distance.

But on the western flank of the mountain an interesting series of strata appears, all inclining off the mountain slope, exhibiting as seen from this point the following lithological appearances: First appears a heavy mass of Carboniferous limestone, which forms a sort of abrupt foreland reaching well up on the western flank of the mountain, and descending into the narrow valley of a small tributary which gains the north bank of Buffalo Fork a short distance below the great gorge. In the opposite acclivity of this little valley appears a set of strata, which probably represent the siliceous beds in the upper part of the Carboniferous. The upper portion of this slope shows a heavy deposit of deep red beds, interspersed with beautiful green herbage-clad slopes, the stratigraphic position and lithological character of which refer them with little doubt to the Triassic. In the gentler western slope appear less distinct exposures of light-drab deposits, with interlaminated indurated, probably calcareous, layers, which may pertain to the Jurassic. And in the undulating slopes intervening between this point and Station XLVIII, the light and buff-gray arenaceous clays and sandstones of the Tertiary succeed, as has already been noted in connection with the observations made at that locality. The Carboniferous and Mesozoic beds incline at a rather steep angle to the westward, and appear to fold round the northern flank of the mountain, in the slopes descending into the valley of Pacific Creek. This feature was especially remarked from Station XLVIII, from which point of view a high crown of the mountain to the north of the cañon slopes shows a series of buff, rusty buff, and reddish streaked beds, probably representing the Silurian and lower beds of the Carboniferous, dipping steeply to the northward. On the opposite or southeast flank, which falls into a broad depression opening between the upper valley of Black Rock Creek and the Buffalo Fork, the strata rise up on the mountain presenting escarped exposures facing Buffalo Fork Peak and the cañon. On the outer slopes the "red beds" reach up several hundred feet, apparently curving round this side of the mountain conformably with the Carboniferous and older sedimentary formations. This feature is finely displayed from the heights just south of Togwotee Pass, a few miles to the east-southeast; but the intervening undulating surface seems to be covered with the *débris* of the volcanic deposits, so that the "red beds" may constitute the latest of the sedimentary deposits visible.

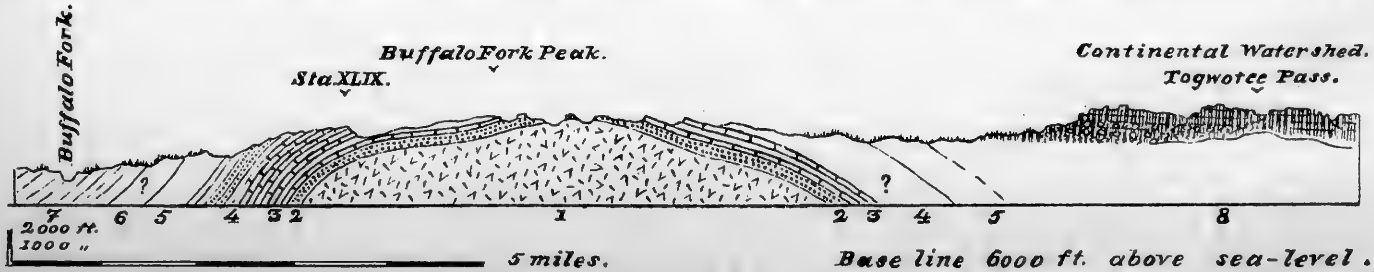
PLATE XLIV.

SECTION ACROSS THE BUFFALO FORK MOUNTAINS. STATION XLIX.



1. Archæan. 2. Quartzite. 3. Quebec. 4. Carboniferous. 5. Trias. 6. Jura. 7. Tertiary, with lignite. 8. Volcanic breccia and conglomerate

SECTION ACROSS THE BUFFALO FORK MOUNTAINS, SOUTH SIDE OF BUFFALO FORK.



THE CONTINENTAL WATERSHED, VICINITY OF TOGWOTEE PASS.

The Black Rock Creek, near the foot of Station XLIX, opens into a fine, high, shallow basin, which extends thence in an easterly direction several miles to the summit of Togwotu Pass, where the altitude is, according to Captain Jones, 9,621 feet. The ascent of the valley is over successive benches having something the character of morainal accumulations, through the lower edges of which the stream breaks its way in narrows, opening above into beautiful park expanses, diversified with grassy slopes and forest-clad border hills. The southern hills are very generally clothed with spruce; the opposite slopes, exposed to the sun, appear to be the congenial *habitat* of the pine. In the lower portion of this valley we meet with red earth, supposed with good reason to be derived from the disintegration of the Triassic "red beds," and wherever these deposits occur in valley depressions they are associated with luxuriant herbaceous growth. Indeed the valley, like so many of the pass-valleys in this region, is excavated out of these deposits. In the slopes south of the stream obscure exposures of light-drab indurated calcareous deposits occur, and at one point in the south bank of the creek, these show a limited bluff exposure of light-drab clays and light fragmentary limestone, dipping gently southwestward. Although no fossils were observed in these deposits, they are believed to belong to the Jurassic. Beyond the latter, to the south, such exposures as are visible in the forest-clad outlying slopes of the volcanic-capped crest south of Togwotee Pass, show light-brown earthy deposits, gently inclined south or southwestward, which appear to merge into the deposits constituting the axial ridge of the Mount Leidy highlands. Higher up the valley brown shaly sandstone layers are apparently associated with these deposits. The banks of the stream also exhibit exposures of a steel-brown deposit like that resulting from the decay of the volcanic breccia. As we pass up the valley the breccia hillocks become higher and more rugged, and associated with the igneous bowlders scattered over the surface, others of hard sandstone, and other quartzose rocks occur, which were probably brought down from the neighborhood of Buffalo Fork Mountain. There are a variety of products referable to volcanic origin besides the generally prevalent breccia, and in the banks of the stream occur banded dark-brown and drab soft sands, nearly horizontal or slightly inclined southward. The trachytic breccia and huge masses of the sombre, green-tinged conglomerate become more and more abundant, and in places are noted heavy-bedded horizontal ledges of reddish-brown weathered porphyritic trachyte. The breccias appear in particularly rugged exposures in the west slope of the summit, where they show exposures of 50 feet in thickness, at an elevation of 700 to 900 feet above the lower end of the valley where they were first encountered.

The approaches to the summit of Togwotee Pass are easy, and the spot itself is one of the most interesting, both for its geologic as also its picturesque surroundings. It is filled with open grassy undulations whose hollows hold pretty lakelets, the declivities dotted with beautiful groves of pine and spruce, and threaded by tiny rivulets bordered by charming little intervales, and miniature terraces bright with many-hued flowers and the white blossoms of a delicate clover. Densely wooded taluses sweep up into the mountain heights on either hand, whose lofty, precipitous walls form a majestic gateway to the pass across the great watershed.

The mountain on the southwest side of the pass afforded a good opportunity to gain a general knowledge of the character of the vast sedi-

mented volcanic accumulations out of which these mountains have been sculptured. The summit of this peak rises a thousand feet above the pass, and on all sides its slopes are steep, on the east precipitous. The above-mentioned sombre volcanic breccia enters largely into the formation of the basis of the mountain, reaching more than half-way to the summit. Then succeeds several hundred feet thickness of partially exposed breccias, the steep slope covered with *débris* up to the shoulder, from which rises the huge angular block that crowns the summit of the mountain. The basis of this block is formed of drab breccia and incoherent or partially consolidated volcanic sands. A thickness of 20 feet of conglomerate forms the plinth. The latter ledge presents great variety in its components, bowlders and pebbles smoothly rounded, of various shades of pink, drab, and red trachytes, porphyritic trachytes, basalt, &c., which have a more or less distinct bedded appearance (in the mass this is even conspicuously displayed) interlaminated with laminated soft sands which are very irregularly distributed through the mass, though having every appearance of aqueous deposition, and a general horizontal arrangement in more or less heavy beds. Seams or laminæ of calcite were observed in this bed. The uppermost deposit shows a thickness of above 50 feet of a brecciated mass, consisting of angular fragments of various kinds of volcanic rocks held in a fine, soft drab-gray paste. These masses, by weather action, are wrought into many curious shapes, rent and fissured and pinnacled, with cornices and ashy, sandy taluses, which give to the mural exposures, seen at a distance, the sombre and light-gray banded appearance which render their recognition so certain wherever they appear.

Notwithstanding the smoky state of the atmosphere, the view from this high station was of unusual interest. The opposite side of the pass is walled by far grander escarpments of the fragmental volcanics which have intimate connection with a mountain ridge extending many miles to the eastward, where it merges into that portion of this great volcanic highland belt to which Captain Jones applied the name Sierra Shoshone. This east-west ridge, itself of titanic proportions, forms the water-divide between the sources of Buffalo Fork and the northern affluents of Wind River, and throughout it presents the same stupendous mountain wall. The main Wind River heads in the angle formed by this ridge and the northern extension of the Wind River Range on its southwest. The latter ridge is capped for a few miles by the volcanic breccias, a long, spur-like ridge putting out from the peak of Station L, which was located on the above-described mountain on the southwest side of the pass. But a little to the east, or southeast, the main crest of this ridge is formed of heavy deposits of dark, sombre, basalt-like lava, which stretches for many miles along the level, wooded crest, presenting a low mural break facing Wind River Valley. In the midst of this ridge, about five miles southeastward of Station L, the surface swells up into a low flat dome, composed of dark and red scoriaceous lava, which forms slides of deep red *débris* in the mountain side. It may be that this dome, on which Station LI was made, marks the site of a gigantic crater from which issued the volcanic effusions that make up the bulk of the mountain crest. I am indebted to my young friend Stephen Kübel, assistant topographer, for the following details in relation to the disposition of the volcanic products in the vicinity of Station LI, as derived from his observations and specimens brought to camp. The highest part of the summit shows a cap of black, more or less scoriaceous lava, underlying which occur red and yellow scoriaceous lavas, the latter apparently forming an intermediate belt between the black and the red, as appears

when viewed at a distance; the red lava forming the principal material in the great *débris* slide in the east face of the mountain. In the lower portion of this slide fragments of a more compact trachytic variety of red lava were found. In outlying ridges, at the foot of the steep ascent, a grayish, thin-bedded, slaty volcanic rock occurs, the ledges much disturbed, being tilted in various directions. Near by large masses of dark rusty volcanic rock occur, which may be the same as that forming the level crest of the flanking ridge. These data furnish conclusive evidence of the volcanic character of an extensive belt along this part of the watershed; just how far to the southeast it extends, I cannot say, though it is my impression that it reaches in that direction more than half the distance from Togwote Pass to the Warm Water or Union Pass.

An arm of what may be termed the Togwote Mountains, comprising the volcanic-capped watershed between Buffalo Fork and the extreme eastern sources of Snake River and the Wind River drainage, which reaches westward into the depression east of Buffalo Fork Peak, shows the volcanic breccia deposits gently uplifted, as though they had partaken to some extent in the upheaval which brought to view the Archæan rocks in the Buffalo Fork quaquaversal. Looking northeastward from Buffalo Fork Peak, further evidences of disturbance are noted in connection with the volcanics that form the distant ridges about the sources of the Yellowstone and Buffalo Fork, to the southeast of Two-Ocean Pass. Dark banded deposits in that quarter, apparently volcanic, show a broad, shallow synclinal, the axis of which seems to run in a southwesterly and northeasterly direction. But in the point between Lava Creek and Buffalo Fork, these deposits, appearing in gigantic escarpments rising into high, bare mountain ridges and plateaus encircling the ultimate sources of this drainage, are quite horizontal, or but very slightly inclined in the exposed faces presented to view from this direction.

This whole region is one of most forbidding grandeur. The volcanic crests all rise above timber-line, while their precipitous sides show the dull banded volcanic ledges almost destitute of vegetation. But the taluses are generally heavily wooded, and at the time of our visit immense columns of smoke from forest conflagrations rose high in air, in places blotting out the view of distant mountains.

CHAPTER V.

ARCHÆAN AREAS.

In the extreme southwest corner of the district surveyed, a limited belt of Archæan rocks extends northward from the Mount Putnam zone, but is much obscured, if indeed it shows a fair exposure at all in our district, by Pliocene and detrital materials which cover the western flank of the mountain immediately south of the cañon of Ross Fork. But just over the line within the territory assigned to Messrs. Peale and Gannett, these rocks attain the magnitude of heavy deposits, consisting of green chloritic slates and quartzites, which in Mount Putnam are tilted into a vertical position, with perhaps slight general inclination from the vertical a little south of east. Still farther to the south they may be advantageously studied in the section along Portneuf River where it cuts across this mountain ridge on its way to the Snake plain.

Over the mountainous region extending east from the Snake plain, in which is found a system of extraordinary plications in the earth's crust, none of the ancient crystalline rocks are brought to view, unless such may have appeared in some of the deep basin depressions, where, however, subsequent effusions of volcanic matter and accumulations of quaternary materials have sealed from view the vestige of these rocks. It is not until we approach the culminating crest of the district that these rocks are encountered, and where their erosion has produced some of the most sublime and beautiful mountain scenery in the Northwest. The nucleal rocks of the Téton Range are composed of rocks of this age. Their distribution and general characteristics have already been noticed in the detail account of the examination prosecuted in this quarter, and it is only necessary to briefly mention their occurrence in this place.

It is evident, even after so cursory study as the past season allowed, that the metamorphic or gneissic and schistose varieties of rocks constitute by far the most prevalent rocks of the Archæan series in this region. But in the cluster of peaks surrounding Mount Hayden as well as the noble peak itself, a light and flesh-colored granite forms the core upon which atmospheric erosion has wrought with so wonderful results in mountain architecture. As seen from the opposite side of Jackson's Basin, the mass in the great peak seems to have a bedded structure, with dips, according to Professor Bradley, but little from the vertical; but from the west the mountain presents vertical precipices of enormous height, in which the granite appears in huge angular blocks or slab-like masses with polished, glistening surfaces. To the north the Archæan area expands, occupying quite the entire breadth of the range along a line drawn through Mount Moran, and over the greater part, if not the whole, of this bared area the rocks are gneissic, or such their peculiar sharp, jagged manner of weathering pronounces them. Immense surfaces of the rocks in this quarter are laid bare by erosion, in which former glaciers may well be credited with an ample share. The crest of this expanded belt forms a prominent spur which abruptly terminates

PLATE XLV.

Eruptive Rocks, Willow Creek Basin.
(Looking East.)

in a conical peak overlooking the great western foreland, in the vicinity of the sources of North Fork of Pierre's River and Leigh's Creek, the upraised volcanics of the foreland here, as to the south, coming into direct contact with the Archæan rocks. But to the north of this great spur the watershed crest is soon capped by the Silurian, the Archæan being crowded to the eastern border and finally abruptly terminates in a comparatively narrow, low ridge, beyond which spreads the high volcanic plateau separating the Henry's Fork drainage from the lake region. This northern terminal ridge, like Mount Moran, lies to the east of the water-divide of the range, and its northeast flank Professor Bradley found partially enveloped in a remnant of Palæozoic deposits. But south of Jackson's Lake, to the vicinity of the cañon of Fighting Bear Creek, the whole eastern face of the range shows the bared Archæan ledges in one of the most majestic mountain fronts on the continent. South of the latter point the heights are crowned by the sedimentaries, which gradually increase by the addition of successive formations in the order of their superposition as the Archæan nucleus declines in elevation, until, at the southern extremity of the range, the sedimentaries lap continuously over the mountain ridge in a series of folds whose continuity in the direction of their longitudinal axis seems to have been broken by the mountain corrugations in the Snake River Range, which intersect the Téton uplift at a sharp angle.

Along the summit of the range to the south of West Téton Creek the Archæan rocks at first occur in a narrow belt, with ganglion-like expansions or isolated areas in the beds of the amphitheatres in which the main west-side drainage is gathered before it flows out into the basin through the gorges the streams have cut across the sedimentary foreland. This southern extension of the Archæan also appears to be largely composed of gneissose and schistose rocks, the structural features of which, however, are too indistinct to be readily made out except by numerous and careful examination, for which purpose our time was far too limited.

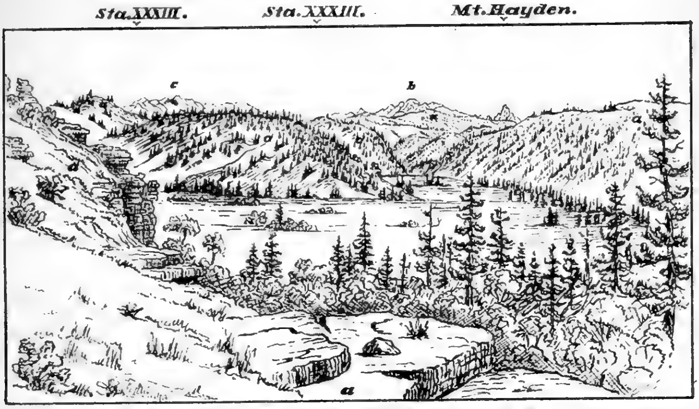
The stupendous elevatory movements in which originated the range, resulted in a vertical displacement of probably not less than 15,000 feet. It appears to have been a long elliptical zone, along the eastern border of which the forces were concentrated, resulting in the tilting of the mountain mass with abrupt dips on the east and more moderate inclination on the west; while in the central portion, in the vicinity of the present dominating heights, it is almost impossible to believe otherwise than that the upthrust of the granitic core completely severed the sedimentary and metamorphic crystalline mantle. Along the greater extent of the eastern front the displacement was probably abrupt, and if it did not result in the faulting of the sedimentary deposits, it so fractured them as to give easy access to those potent agents in mountain degradation resident in the atmosphere, and which have left but the meagre skeleton of the foundation of this side of the range, from which we may endeavor, with greater or less success, to conceive the mighty changes that have been wrought in the lines of its contour, and rehabilitate the mountain to its prime.

The Gros Ventre Range shows a less lofty and more uneven Archæan belt, the rocks at the western end consisting chiefly of much distorted gneissic and schistose ledges. As in the Téton Range the disturbances to which these early metamorphic rocks were subjected prior to their upheaval in the present mountain range, the few facts we possess throw little light on even the general phases of these early movements; but in the later upheaval the records, as laid open to inspection by erosive

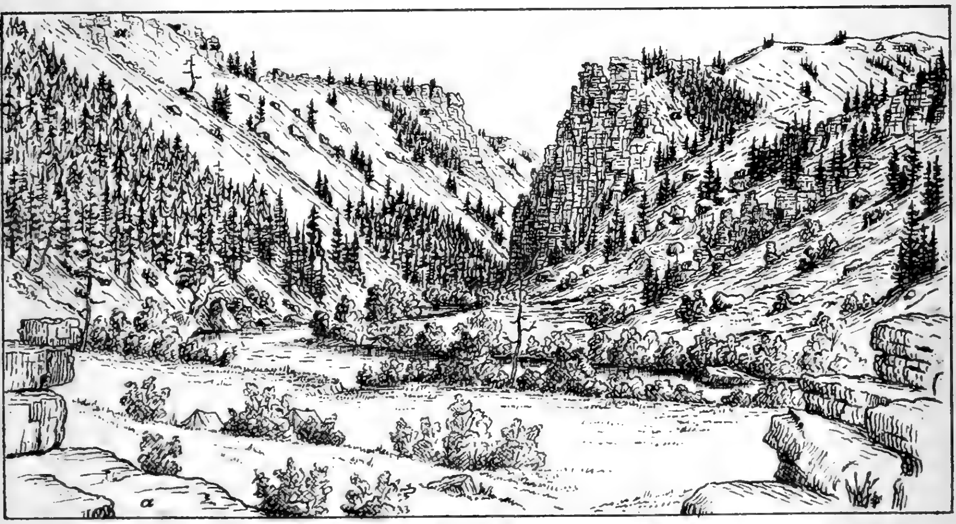
agents, are clear and readily intelligible. The elevation of the range appears to have been effected by a series of parallel folds, trending generally southeasterly and northwesterly, and culminating along the southern border where the Archæan nucleus is upthrust in a great wedge-shaped mass, the degradation of which has produced a symmetrical cone something like the sharp ridge peaks and aiguilles in the Tétons. The eastern portion of the crest of the range, I believe, has never been approached, so that we are unable to say what the relations of the nucleal rocks are in that quarter. So far as could be determined from the heights at the western extremity to the eastward the Archæan core gradually sinks, admitting a greater and greater depth of sedimentaries to rest upon the axial region.

The range forms a sort of transverse bar or truss connecting the Wind River Range with the Tétons. Dr. Hayden in 1860 found the saddle at the eastern end filled with Tertiary deposits, which rise high up on the opposite or western flank of the Wind River Mountains. In a preceding page it was stated that to the west the Archæan ridges sink and are plated with the sedimentaries, so that while this relationship to the two great ranges is quite marked as a topographic feature, geologically considered it probably forms an independent uplift, the exact date of which I am unable to state, although it was at a comparatively modern period, as evidenced by the tilted position of the Pliocene beds that dip gently off the flank of the range in the borders of Jackson's Basin. This fact alone would lead to the inference that the Gros Ventres have been subjected to elevatory movements which were continued after the deposition of the Pliocene lake-beds to a very recent date compared with any records of similar movements in the range of the Tétons.

To the north of the Gros Ventre Range, and a few miles west of or about midway in the western slope of the continental watershed, Buffalo Fork of Snake River has excavated a deep, flaring cañon across a dome-shaped uplift, the nucleal rocks of which consist of much contorted, ferruginous-stained gneissose ledges, of which a height of several hundred feet is exposed, forming the abrupter walls of the gorge. This is probably the locality referred to by Professor Comstock in his report to Capt. W. A. Jones on the geology of the country traversed by the military reconnaissance of Western Wyoming, 1873, p. 105: "Between the Two-Ocean Pass and Togwotee Pass there are exposures of a metamorphic group which undoubtedly represent the ridge of some mountain range or its spurs, though it is a difficult matter at present to define its relations to the main chains." The date of this uplift, however early its inception, must have extended to a period subsequent to the deposition of the Tertiaries, which latter both Professor Bradley and Professor Comstock report as being much disturbed on the flank of the mountain; and, as elsewhere remarked, there are some grounds for the belief that even the latest of the later volcanic accumulations, the great breccia conglomerate, may have to some slight degree at least partaken in this upward movement. Once comprehending the isolated position of this bulged-up mountain mass, the mind naturally seeks some explanation of the origin of the gorge which separates the dome into halves, and whose bed is at present threaded by the diminished channel of Buffalo Fork. The apparent continuity of the Palæozoic deposits which reach up into the very crest of both the north and south side mountains, and which once doubtless spanned the chasm that now divides them, militates against the supposition that the course of the present stream was marked out by, or followed a fracture or crevice across the mountain; and although the results of upheaval are here manifested in an extraordinary



Volcanic Foreland on North Fork Pierre's R. (Looking S.E.)
a. Volcanic. b. Archæan. c. Palæozoic.



Cañon of North Fork Pierre's River.
a. Laminated porphyritic trachyte. b. Pink trachyte.

manner by the steeply tilted beds that lap up on the sides of the mountain, there is, perhaps, no necessity for referring the results to more violent manifestations of disturbance than those accompanying the very gradual and long-continued elevatory movement which, only allowing time, would be sufficient for the elevation of the mountain into its present magnitude, and the erosion of the predetermined stream-bed to its present depth in its passage across the disturbed area.

Although the southeast corner of our district includes the Archæan zone of the Wind River Range, at no point did opportunity offer to penetrate this interesting region. But we know its general features from the early explorations of Dr. Hayden, who reported the northern continuation of the watershed north of Union or Warm Water Pass to be enveloped up to a high altitude by Tertiary deposits and capped by volcanics, as we found to be the case in the neighborhood of Togwotee Pass, where not the vestige of Archæan nor Palæozoic rocks, *in situ*, were observed.

PALÆOZOIC AREAS.

Besides the Palæozoic belts that encompass or partially surround and reach up on Archæan areas, in whose elevation they have likewise participated, there are considerable zones of rocks belonging to this era in various parts of the district, the upheaval of which, although accompanied by extraordinary displacements, did not bring to view the crystalline basis-rocks. The greater portion of the south and southwest is occupied by upheavals of the latter class. But it will perhaps facilitate the review of this series of formations briefly to define the geographical position of all these areas. Commencing on the western border, they may be considered in the progressive order of their occurrence to the east.

In the extreme southwest, the monoclinal ridge which finishes off the northern terminus of the Mount Putnam, or more properly the Portneuf Range, exhibits apparently the full series of Palæozoic formations, as they are here developed, reclining upon the eastern flank of what was doubtless once an anticlinal fold, whose western declivity was denuded in the course of the erosion of the great basin of the Snake.

To the northeast of the Putnam hills a few miles, these formations have been brought up in an approximately parallel low ridge southwest of the Blackfoot, in which the upper siliceous beds of the Carboniferous have been tilted into nearly vertical position—indeed, sometimes past verticality—where the quartzitic ledges give origin to the rather prominent crests of Higham's Peak. A few miles north of the latter point the ridge is completely cut down in the cañon of the Blackfoot, in the walls of which Dr. Hayden, in 1871, observed nearly the full series of Palæozoic rocks, dipping to the eastward and covered by the upraised volcanics. Although this ridge presents a rather well-defined topographic feature, geologically it is much complicated, the southern and northern folds in which these rocks appear belonging to two very distinct sets of dynamical actions which intersect one another nearly at right angles, the southern of which belongs to the Mount Putnam system of folds.

In the much-disturbed region of the Blackfoot Range, next east, and the low parallel basin ridges southeast of the southern extremity of that range, with a single exception, no rocks of an earlier date than the Carboniferous were met with. This belt is almost coextensive with the length and breadth of the range, and at the south it embraces a limited

patch of Carboniferous, which is detached from the main ridge by a depression floored with basalt.

Along the northeastern border of the Caribou Range occurs a narrow strip of Palæozoic deposits, extending a distance of 20 miles in a northwesterly and southeasterly direction below the narrows in the lower valley of the Snake. The older deposits are mostly covered by volcanic flows, but the Carboniferous is finely displayed, especially the upper horizons, in the lower flanks of the range, inclined to the southwest. It appears that these deposits once arched over the trough of the present valley of the Snake, which was excavated along the crest of an anticlinal fold, or a series of sharp folds, in this part of its course.

In the Snake River Range, on the opposite side of the valley, there are apparently two parallel belts of Palæozoic strata, of which the southwestern reaches probably the entire length of the range, forming a gradually expanding belt along the southwest border of the range to the southeast. On the opposite side of the range, what remains after the erosion of Pierre's Basin, constitutes an irregular, narrow belt, which shows its greatest breadth to the northwest, in the Pierre's Mountains. Both these zones are Carboniferous in their constitution, which constitute the most ancient of the sedimentary formations as yet detected in this range. They appear to have been raised up in great folds, that to the northeast, bordering Pierre's Basin, being accompanied by abrupt flexure or faulting, with downthrow on its northeast side.

The Téton Range exhibits by far the most considerable area of these rocks. The vertical displacement accompanying the upheaval is measured by thousands of feet, or between three and four miles, and on the slopes of the Archæan axis almost if not the entire Palæozoic series is laid open to view in the gorges which the streams have eroded out of their substance. They constitute a heavy plating along almost the entire western declivity of the range, their continuity being interrupted over a space of only a few miles across, between Bear Creek and the north fork of Pierre's River, where they have been denuded, the subsequent volcanic flows impinging on the granites. But to the north and south they fold quite round the extremities of the range, and it is in the latter quarter they maintain their complete development, preserving the topmost siliceous horizons of the Carboniferous, immediately succeeded by the superimposed Triassic "red beds." The series as here constituted embraces the quartzites of the Potsdam, the Quebec Group limestones, the Niagara dolomitic limestones, and the Carboniferous, a generalized section of which will be given presently.

Assuming the movement to have been gradual, it seems almost certain that the elevation of the range began to the north, where we find it has been subjected to the greatest amount of erosion, which has bared the Archæan nucleus over an extensive area, and swept the Palæozoics from the entire breadth of the range. The precise date of the inception of the elevatory movement may be beyond determination; but, relatively, it belongs to a post-Jurassic and possibly even to Cenozoic time, although it is believed to have preceded the elevation of the Snake River Range, which latter movement involved a set of early Tertiary deposits, Laramie (?), of which there has been observed as yet not a vestige in the Téton Range proper. But this movement has continued up to a late date as evidenced by the inclined position of the volcanics on the flank of the mountain.

In the Gros Ventre Range the Palæozoics occupy an area only less extensive than that in the Téton Mountains. Also there here occurs the same series of formations, but they have not been subjected to the

same excessive denudation, the northern flank of the range at least bearing a heavy protecting mantle of early Mesozoic strata. However, in the interior portion of the range they are bared in magnificent escarpment exposures, the various formations impressing their individual characteristics on the mountain topography.

The Buffalo Fork Peak uplift has brought to light an equally interesting exhibition of the Palæozoic rocks, and associated with phenomena which may have important bearing on the physical history of the era in this quarter. The quartzite and Quebec Group limestones, although holding a prominent place in the stratigraphy, do not attain the same degree of development as do the same deposits in the Téton Range. And in connection with this attenuation of the upper limestone of the Quebec, there appears to have been no cessation in the deposition of calcareous matter, and the one or two hundred feet of passage limestones intervening between the Quebec and Carboniferous deposits, if they prove to be Niagara at all, show the same diminution in the amount of limestone-making materials that were here thrown down upon the sea-bed during that epoch. The Carboniferous, however, apparently attains its usual development, and in the character of its components and lithology the closest agreement obtains with its appearance in the Gros Ventre and Téton Ranges.

From the observations of Dr. Hayden and Professor Bradley, together with such information as was derived during the present season's explorations, the following general section of the Palæozoic series in this district has been prepared:

General section of Palæozoic formations in the Téton district.

PALÆOZOIC.	CARBONIFEROUS.	PERMO-CARB.		Alternations of more or less arenaceous limestones, sandstones, and gritty shales; 500 and less to 1,000 feet. Permo-Carboniferous division of the Upper Carboniferous.
		UPPER CARB.		Alternations of quartzitic sandstones, gray, more or less cherty limestones, and red shaly layers; 1,000 to 2,000 feet. Upper Coal-Measure division of the Upper Carboniferous.
		LOWER CARB.		Generally more or less cherty limestone, with local interpolations of quartzitic sandstone or siliceous beds, and red arenaceous shales; 1,000 to 2,000 feet, more or less. Lower Carboniferous, including, possibly, several at least locally defined divisions, which resemble similar epochal divisions in the Upper Mississippi region.
	UPPER SILURIAN.	NIAGARA.		Heavy-bedded buff magnesian limestone, usually weathering in castellated exposures; 400 feet and less to 600 feet. In the southwest occurs a local development of light-colored, rough-weathered quartzitic sandstone, 50 feet or more in thickness, apparently occupying the place of the dolomitic limestones. Also local developments of drab shales, 100 feet, more or less, occur in this horizon.
	LOWER SILURIAN.	CANADIAN.	*Quebec Group.*	Generally even thin-bedded limestones; 50 to 200 feet. Upper limestone.
				Shales, more or less arenaceous, with thin indurated arenaceous bands and limestone layers; 200 feet and less. Interchangeable with the above occurs a quartzite conglomerate, 50 to 150 feet thick, forming an inter-Quebec horizon of variable local aspect. Passage beds.
				Limestone, usually thin-bedded, in places brecciated, rusty-weathered, but quite variable in local appearance and vertical extent; 50 to 200 feet. Lower limestone.
		PRIMORDIAL.	*Potsdam.*	Arenaceous indurated deposits, rusty and dirty-yellow weathered, and sandstone, sometimes glauconitic, but also white and variable, based upon quartzite, also variable in color, laminated and conglomeritic; 200 to 300 feet, more or less.
ARCHÆAN.	HURONIAN?			Quartzites, micaceous and chloritic slates, forming heavy deposits several thousand feet in thickness. Developed in the southwest, but apparently absent in the central and eastern portion of the district.
	LAURENTIAN.			Gneisses, various schistose rocks, and granite.

For convenience of reference the lower limestone horizons of the above section are designated by the terms *upper* and *lower* Quebec, by which it is not intended to convey the impression that these beds represent or are the equivalents of the earlier and later depositions during the Quebec epoch,—a determination for which paleontological evidence is at the present time wanting, but which will be of use hereafter in recalling these quite persistent calcareous horizons.

PRIMORDIAL QUARTZITES.

In the extreme southwest portion of the district a narrow tongue of the Huronian (?) quartzites of Mount Putnam extends down to Ross Fork, but it is so obscured by denudation and later deposits as scarcely to be regarded as an element in the present stratigraphic history of the district. Indeed the basis quartzite of the present series, or Potsdam, does not present a fair exhibition in this quarter within the limits of our territory at the points visited the present season. But on the northeastern flank of Mount Putnam, the high northern culminating peak of the Portneuf Range, occurs a considerable thickness of dark, rusty-red sandstone, finely laminated below, presenting a much broken up exposure resting upon the heavy quartzite, which latter runs up into the crest of the mountain. This rusty quartzitic sandstone may represent the Potsdam in this quarter, but the immediately superimposed deposits associated with this ledge are so obscured as to give no clew as to their character.

We do not again meet with authentic exposures of this horizon until reaching the Téton Range. Here they were studied by Professor Bradley, who ascribed to the inferior "very compact ferruginous quartzite" a thickness of 50 to 75 feet. Overlying the latter occurs a space of 200 feet or more in which appear white and reddish laminated quartzitic sandstones, usually evenly bedded, but the exposures are obscure in the slopes below the forks of West Téton Creek where they were examined last summer. But higher up on the mountain Professor Bradley had opportunity to examine this horizon in the free slopes of the high Alpine ridges, where they show "about 300 feet of partly compact and partly shaly glauconitic sandstones, which are evidently equivalent to the so-called Knox sandstones of Safford, which form, in Tennessee, the lower part of the Quebec Group." Professor Bradley observed no fossils in these beds, and he was of the impression that they are "unequally distributed," though, so far as could be determined, they constitute a persistent element in the stratigraphy of this region.

The same set of deposits evidently occurs in the Gros Ventre Range, also in the Buffalo Fork Peak uplift. In both these localities the inferior conglomeritic laminated quartzite and quartzitic sandstone are associated with interlaminations of a beautiful white quartzite in which the grains of silica often have the appearance of the roe of fishes. In the Gros Ventres the quartzite was seen in immediate contact with the unconformable Archæan schists, from which it is separated by a handsome rose-colored, finely-laminated, gneissose lamina, which may be the metamorphosed inferior layer of the quartzite. The overlying portion is made up of rusty indurated layers and dirty-yellow deposits, which, however, do not reach the same thickness as reported in the Téton Range.

CANADIAN.—QUEBEC GROUP.

The identification of rocks of the age of the Quebec Group, in this northwestern region, I believe, was based upon materials brought in by

the expeditions of the survey during the season of 1872, and the collections from the Téton region and vicinity of Fort Hall, made by Professor Bradley, afforded Mr. Meek the means of establishing this identity on paleontological evidence. But in their lithological peculiarities we possess an almost equally sure means of recognizing these deposits, and, in the absence of fossils at many localities, it becomes of great importance to pay close attention to the local phases under which these rocks appear in remote sections of the district. They are believed to be uniformly developed as two distinct limestone deposits, which may be distinguished by the provisional terms *upper* and *lower* Quebec limestones.

Lower Quebec limestone.—In the Mount Putnam ridge, at Station II, the lower Quebec limestone, showing a thickness probably between 200 and 300 feet, is made up apparently of three limestone beds. The lower is a dark gray, even-bedded limestone, overlaid by a rough-weathered buff limestone somewhat resembling the Niagara, the upper bed showing a thin-bedded, dark-gray, brecciated limestone. No fossils were found in these beds. In the Téton Range, especially in the sides of West Téton Creek Valley, this lower ledge shows in an exposed thickness of 50 feet, or more, an even thin-bedded, rusty drab impure limestone, with purer dark-drab layers, traversed by calcspar seams, and containing minute crystals of iron, to the presence of which is doubtless due the brown-stained appearance of the rock in the extensive mural exposures here and elsewhere found. In the Gros Ventre Mountains the ledge exhibits much the same lithological characters above cited. But at Buffalo Fork Peak, where it shows an exposed thickness of 50 to 75 feet, it consists of bluish and dark-drab, brecciated, thin-bedded, rough-weathered limestone, the lower portion brown-gray and dirty-yellow stained, also destitute of fossils. It will have been observed that the horizon presents marked contrasts in the eastern and southwestern areas of its exposure, both as regards its lithology and the comparative duration of the conditions favorable for the accumulation of its component materials, which in the latter quarter allowed the deposition of a thickness of calcareous sediments more than double that which obtained in the Tétons and to the east.

In the Téton Range the intermediate or passage beds between the upper and lower Quebec limestones were at no point visited revealed, the slope, usually short, between the two almost invariably showing a steep *débris*-covered talus; as was also the case in the Gros Ventre Range. But in the Buffalo Fork Peak the component strata of this horizon are well displayed, presenting below yellowish areno-micaceous clays, with indurated layers charged with a small orbiculoid shell and thin layers of dirty-drab limestone, on the weathered surfaces of which are crowded the fragmentary remains of Trilobites and other fossils; among others there have been identified the genera *Conocoryphe* and *Dicillocephalus*. The upper portion of the deposit is here composed of bluish-drab shales and brownish-gray shaly sandstone, the latter probably corresponding to the indurated arenaceous layers with the orbiculoid shell above mentioned. The deposit at this locality probably reaches a thickness of between 100 and 200 feet, and the fact of its satisfactory exposure is due to its position in the crest of the elevated ridge culminating in Buffalo Fork Peak. The supposed equivalent horizon in the Mount Putnam ridge north of Ross Fork, at Station II, is occupied by a heavy ledge of conglomeritic quartzite, which shows in exceedingly rough-weathered exposures 40 to 50 feet in vertical extent, but it is probably thicker, the space above and below, together with its outcrop, reaching 100 to 150 feet. The character of the associated deposits immediately above and below was not as-

certained, but from the appearance of the slopes, their soft shaly nature may be inferred. The conglomerate seemed to be without fossils. The occurrence of this deposit marks a prominent change in the relative coarseness and degree of induration of the materials accumulated in this quarter, though their derivation in both cases is, with our present meagre information, involved in much obscurity.

Upper Quebec limestone.—The upper Quebec limestone shows almost the same development in the three principal areas, and wherever it occurs it is characterized by a fossil fauna, whose species are represented by an abundance of individuals. The Mount Putnam ridge, at Station II, is capped by this member, where it shows a thickness of perhaps 200 feet. The rock consists of generally thin-bedded, fragmentary, sometimes brecciated limestone, in color gray, grayish-buff, and pinkish tinged, with buff indurated or shaly partings, certain layers being charged with the disjointed or fragmentary remains of small-sized Trilobites and a little Gasteropod resembling *Raphistoma.*

In the west flank of the Téton Range, wherever the series is exposed, this horizon takes a prominent place in the stratigraphy of the magnificent sections here displayed. Its mural exposures, showing an exposed thickness of 100 feet or more, are traced for miles in the cañon walls and as outliers in the Alpine region of the mountains. The peculiar brown color of the weathered exposures, as well as the even-bedded structure of the deposit, resemble those features of the inferior ledge. In West Téton Creek Cañon the main portion of the rock consists of dark bluish and bluish-drab, even and thin-bedded, sometimes shaly, more or less pure limestone, in places mottled with dirty-yellow spots, the exposed surfaces of the layers presenting the peculiar rough-weathered appearance so commonly associated with this rock. Above the rock seems to pass through a gradation of thin shaly layers into the overlying shales, this portion of the exposure usually presenting a rusty yellow appearance. In *débris* at the mouth of the cañon, probably derived from this horizon, a few fragments of Trilobites were found.

On the western flank of the Gros Ventre Range, south of the Little Gros Ventre, these strata are raised up on the mountain, and also appear in mural exposures at various points in the higher interior portion of the range. It is here a drab, thin-bedded limestone, the exposed bedding surfaces roughly weathered, the escarpment exposures showing the characteristic dark rusty, even-bedded outcrop, and a thickness of 100 feet or more. The rock is traversed by thin seams of calc-spar, giving it a mottled appearance, and breaks into small fragments under the hammer.

To the northeastward the horizon becomes much attenuated, as shown in its outcrop at Station XLIX, in the vicinity of Buffalo Fork Peak. At the latter locality the bed is made up of drab, buff-mottled, shaly, or thin-bedded fragmentary limestone, exposed thickness 50 to 75 feet, and contains the broken parts of Trilobites and other fossils. Of the isolated remnant preserved in the Upper Gros Ventre Butte, and which may properly be referred to the Téton area, I can add nothing from personal examination to the mention it received from Professor Bradley.

The Quebec-Niagara beds of passage.—The horizon of the beds of passage between the Upper Quebec limestone and the next succeeding limestone above, offers most interesting phenomena of the varied physical conditions prevalent during this epoch within the limits of the present district. So far as our present knowledge extends, it is difficult to assign to the time conditions productive of particular or normal results, so different were the materials deposited at this time in different portions of

the region, and indeed the apparent omission in certain localities of any cessation in the conditions favorable to the accumulation and deposition of calcareous matter, by which the Upper Quebec limestones were made to form part of an uninterrupted series of limestones reaching up into the Carboniferous.

In the southwest the horizon is occupied by a heavy ledge of light-colored, rough-weathered fragmentary quartzite or quartzitic sandstone, of which a thickness of at least 50 feet is exposed in the Mount Putnam Ridge. Low in the southwest flank of the Blackfoot Range occurs a conglomeritic quartzite, which may be the equivalent of the above-mentioned ledge. It is also possible that the similar quartzite, remnants of which outcrop in the edge of the lower valley of the Snake, along the northeastern foot of the Caribou Range, may belong to the same horizon. But in the Téton Mountains the siliceous, or, at least, the quartzitic materials are replaced by argillaceous matter, and which occupies a vertical space of, perhaps, 100 feet. The exposures were at no place sufficiently free from *débris* as to admit of satisfactory examination of the horizon. But in the sides of West Téton Valley slide exposures are met with at this horizon, revealing drab clay shales, and throughout this quarter the space between the Upper Quebec and Niagara limestones shows a steep talus, or sometimes a bench of greater or less width, indicating the presence of subjacent soft deposits. Such is the character of the horizon in the western portion of the Gros Ventre Mountains, with, however, indications of the presence of interlaminated indurated calcareous material. But to the northeast, in the vicinity of Buffalo Fork Peak, these deposits are absent, the Upper Quebec limestones being followed by apparently conformable limestones, which pass up into well-determined Carboniferous deposits.

NIAGARA.

In 1871, Dr. Hayden discovered in the Wasatch Range, vicinity of Ogden, Utah, rocks of the age of the Niagara of the East, a determination made on the occurrence in the limestones of the coral *Halysites catenulata*. In the northern extension of the same general mountain range, where it sinks to the level of the Snake plain, at the northern terminus of the Mount Putnam ridge, Professor Bradley, during the following season, recognized, on stratigraphical position and lithological characters, the same formation. But in this latter ridge, at Station II, it is evident that the Niagara is wanting, the more or less magnesian limestones, containing crinoidal and other Carboniferous fossils immediately succeeding and resting upon the quartzitic sandstone which here constitutes the passage bed interposed between the Upper Quebec and Lower Carboniferous limestones. It is not improbable the same state of things exists in the Blackfoot Range; at all events, no rocks of Niagara age were identified in this quarter during the present season. Professor Bradley mentions the occurrence of light magnesian limestones at the north end of the Caribou Range, which, lithologically, bear close resemblance to Niagara beds in the Téton Mountains, a determination which, although the exposures in this vicinity are not so satisfactory as could be wished, is probably well founded.

In the same manner was the lower magnesian limestone horizon in the Téton Range identified with the Niagara beds occurring to the southwest. During the present season the above determination of the age of the latter deposit was fully confirmed by the discovery of the presence in these beds, at the northern end of the range, of *Halysites* and other

characteristic Upper Silurian corals. The rock in this region is pretty uniformly a heavy-bedded, light to dirty buff, in places reddish-stained, magnesian limestone, attaining a thickness of from 400 to 600 feet. Wherever erosive action has laid it bare, as in the cañon sides and great promontories overlooking the Alpine basins in the heart of the range, it presents peculiarly characteristic exposures, picturesque castellated cliffs, and massive foundation walls which support the more fragmentary superimposed Carboniferous deposits. In many of its features, even the peculiar rough pitted manner of weathering, and its porous or minutely vesicular structure, it strongly recalls the Niagara magnesian beds, whose bluff exposures form some of the most picturesque scenery along the shores of the Upper Mississippi.

The same deposit appears in the Gros Ventre Mountains, where it also maintains about the same thickness. In the Buffalo Fork Peak uplift, however, it is greatly attenuated, if indeed it at all exists. At Station XLIX, in the latter region, a vertical space of about 200 feet intervenes between the uppermost layers of the Quebec limestone and the summit of the station, and which is filled by gray, reddish-stained, cherty limestones, the summit ledges and a hundred feet below holding characteristic Carboniferous fossils. There are no indications of nonconformity between any of the above-mentioned deposits at this locality, and the appearances point to the conclusion that the deposition of calcareous or limestone-making sediments was uninterrupted from the commencement of the upper limestone of the Quebec to the Carboniferous. The lithological distinctions between the Quebec and the overlying limestones are sharply drawn, while the immediately superimposed limestone layers do not differ in any marked degree from the higher layers containing Carboniferous fossils; so that if they do belong to the Niagara period, they were not affected by or did not participate in the transformation which elsewhere converted the entire horizon into a dolomitic deposit.

CARBONIFEROUS.

Rocks of the age of the Carboniferous are extensively developed in the district, constituting a most important element in the stratigraphy of its orographic reliefs; indeed whole mountain ranges are carved almost entirely out of deposits pertaining to this age. A generalized section of these rocks falls into two categories or great divisions, viz, Lower and Upper Carboniferous, the persistency of which may be considered as being more or less well established. The great divisions, or periods, seem to be further divisible into what may prove to be more or less well-defined subdivisions, which may in part correspond to the epochs which marked the various life stages of these periods in other regions. Although it has not been possible to define the limits of these lesser divisions, or to establish the relations of the faunal assemblages contained therein to those which characterize definitely determined horizons in rocks of this age in longer known and more thoroughly studied localities, at least some evidence, which seems to point to their existence in reality, has been observed, so that their general outlines may be stated with a degree of confidence. Such as they were found to be, within the limits of the present district, are briefly sketched in the following pages.

Lower Carboniferous.—The time of the inferior division of the Carboniferous was eminently a limestone-making period, with, however, infusions of siliceous matter, which became seggregated mainly in the form of chert, in both nodules and layers, with occasional heavier siliceous deposits or quartzitic sandstones. The local lithology and chemical char-

acter of the limestones is subject to local variation, but to just what extent these changes are manifested will require much patient research to determine. In the aggregate, this division attains a thickness of 1,000 to 2,000 feet, approximate.

In the Mount Putnam Ridge the basis rocks show a heavy ledge of rough-weathered, buff-gray siliceous limestone, containing a few obscure fossils, crinoidal remains, and a *Hemipronites*. This is succeeded by a heavy bed of light-gray, cherty, rough-weathered limestone passing up into dark bluish-gray rather even-bedded limestone, with black chert, charged with a large *Zaphrentis*, *Spirifer*, &c. In the vicinity of the outcrop of the latter deposits, in the little hill-environed basin of Ross Fork, my notes make mention of a considerable deposit of conglomeritic materials, chiefly composed of light-gray limestone pebbles, with some of quartz, and apparently interlaminated with buff, shaly limestone layers, in which occur fragments of an *Aviculopecten*. The relations of this deposit to the apparently overlying beds above referred to is not clearly indicated, and it is mentioned here that attention may be called to the subject for the future settlement of any doubts that may exist as to its relations to these rocks, with which it seems to constitute a conformable member. The beds above mentioned belong to the lower division of the Carboniferous, and at one point in this neighborhood Professor Bradley discovered in these rocks a peculiarly Lower Carboniferous fauna, many of whose abundant minute forms Mr. Meek found to be specifically identical with those which characterize the Warsaw beds in the Upper Mississippi Valley. All these deposits dip to the eastward, but in the opposite side of the synclinal within the area of a basin at the head of one of the tributaries of the Portneuf, they have been denuded and concealed by late accumulations, only the Upper Carboniferous horizons being seen at this point.

To the northeast, however, in the Blackfoot Range, the lower formations are extensively displayed. Their occurrence in this quarter is also accompanied by evidences of much disturbance, the strata are folded and, perhaps, faulted, on which account, notwithstanding the exceptionably good exposures so prevalent here, it will require much time to acquire familiar acquaintance with the stratigraphic details of the series. These inferior limestones reach a thickness of several hundred feet, perhaps 2,000 feet, including quartzitic horizons and red-stained siliceous deposits in positions below well-marked Lower Carboniferous horizons. Paleontologically, horizons in these cherty limestones are characterized by associations of fossils which have intimate likeness to certain Lower Carboniferous formations in the Upper Mississippi region.

As at the locality in the Mount Putnam Ridge, we here find, in the vicinity of Station X, an eminently Warsaw molluscan fauna. Elsewhere the lithological, as well as the paleontological, resemblances of certain horizons amount to almost absolute identity with the Keokuk formation, as developed in the Western States. At Station VII, in a dark bluish-gray cherty limestone, with lighter colored shaly partings crowded with corals, Polyzoa, &c., a veritable fish-bed occurs, from which were obtained representatives of the Selachian genera *Cladodus*, *Deltodus*, *Helodus* (*Lophodus*), *Petalodus*, *Antliodus*. As is well known, one of the above-named genera, *Antliodus*, is restricted to Lower Carboniferous formations, while all the other forms are closely allied to, if, indeed, they prove not to be identical with, species peculiar to the lower divisions of this series of formations in the Mississippi Valley. The affinities of the fish-remains do not indicate a later date for the beds in which they occur than the Keokuk formation. Hence, so far as the evi-

dence goes, we have good grounds for the recognition of physical conditions, accompanied by organic manifestations, representative of at least two prominent formations of the Lower Carboniferous in this region, viz, the Keokuk and Warsaw beds of the Saint Louis. There also occur in this range certain limestones which are charged with *Lithostrotion* and *Syringopora;* but the relative position of these beds with those above mentioned was not determined. However, in the vicinity of Station IX, the *Lithostrotion* limestone is underlaid by a heavy series of bluish-gray cherty limestone, with *Zaphrentis* and crinoidal remains, which may well embrace the lower horizons. If the paleontological evidence in all cases holds good, then we should infer that the Lithostrotion horizons correspond to the Saint Louis formation.

It is probable that, in the Snake River Range, the Lower Carboniferous formations are well developed, especially in the magnificent natural sections exposed along the lower course of the Grand Cañon. But in the northeastern belt, which alone was penetrated the past season, at only one or two points in the Pierre's Mountains are these deposits well exposed. Here was noted the uppor *Lithostrotion* bearing limestones, and it seems not improbable the older formations may yet be found in their proper order in the ridge terminating in Spring Point. They here exhibit the same lithological and mineralogical concomitants elsewhere prevalent, and wherever the rocks are much disturbed they are, in common with other limestone formations above and below, traversed by seams of calc-spar, which doubtless owe their origin to infiltration.

Little was elicited, in the course of the hasty examination made in the Téton Range, relating to the detail stratigraphy of these lower limestone deposits, beyond the recognition of the various groups above alluded to in the similar faunal associations which also here occur. We also observe in this quarter the frequent occurrence of red-stained beds, and in the vicinity of Station XXXII, at the northern end of the range, these lower horizons are quite siliceous. But at no point visited were the passage-beds at the base of the series satisfactorily revealed, although it is apparent, almost to a certainty, that the space intervening between the Carboniferous and the Niagara limestones is occupied by soft or shaly deposits. Even the Carboniferous limestones appear to be interbedded with shales and shaly layers, which give rise to the step-like steep slopes of their outcrop, which usually weathers in low mural exposures, alternating with narrow taluses, giving to some of the isolated outlines in the higher portions of the range their peculiar pyramidal form.

In the Gros Ventre Mountains, particularly at Station XLVI, we gain a clue to the character of the inferior deposits of this series, as also the nature of the beds of passage. The latter as here exposed show yellow weathered shaly deposits, probably made up of limestones and shales, and which constitute a rather marked band wherever the horizon is not covered with *débris*. The lower limestones are a grayish or bluish drab color, overlaid by dark brownish-drab magnesian layers charged with *Hemipronites crenistria*, or a closely-allied form. The thickness of the limestones intervening between the heavy magnesian limestone of the horizon of the Niagara and the upper red siliceous or arenaceous horizon, which latter may be regarded as the top of the lower series, it is impossible to state with accuracy; but this space appears to be of less vertical extent at this locality than in the Téton Mountains, yet it may reach 1,000 feet.

As has already been observed, in the vicinity of Buffalo Fork Peak the deposition of limestone-making materials went on without interruption from the time of the Upper Quebec limestone to the Lower Carbon-

iferous limestones, while the horizon of the Niagara is greatly attenuated and represented by ordinary limestones difficult to distinguish from the beds which, a little higher up, contain well-recognized Carboniferous fossils. But to whatever period these doubtful limestones belong, there is entire absence of beds of passage of mechanical origin, as arenaceous and argillaceous materials, so that the physical conditions here prevalent were very different from those that obtained at the close of the Quebec and Niagara periods in other portions of the district. At Station XLIX the lower limestones of the Carboniferous exhibit precisely the same features as mark their occurrence in the Gros Ventre Mountains: lower grayish-drab cherty limestones, with crinoidal remains and a medium-sized *Orthoceras*, succeeded by dark drab and brown magnesian beds and buff semi-magnesian limestones, and which probably attain an average thickness.

Upper Carboniferous.—At least in certain areas of their exposure in the district, the interval between what has been regarded as the top of the lower and the base of the upper series of the Carboniferous is occupied by a set of deposits which marks an abrupt break in the conditions under which the heavy series of lower limestones was formed, and which were thereafter never fully re-established. In the Téton Mountains this change was, perhaps, most pronounced, and inaugurated the deposition of arenaceous clays, nodular and thin beds of limestone, finished in a heavy bed of reddish-buff laminated sandstone, and intensely hard, brittle, siliceous layers, the general appearance of which might well lead the observer to mistake their probable relationship and refer them to the "red beds" of the Triassic period. The deposit as here developed ranges from 200 to 400 feet in thickness. Remnants were met with as far north as the great foreland between the West Téton and Bear Creek, but to the south it was seen at several localities fully developed, and the maturer study of the data obtained in this quarter renders almost certain that it properly belongs to the horizon above indicated. The fact of the deposit being finished by hard siliceous ledges has preserved it from destruction over considerable areas in the great foreland south of West Téton Creek, where the superimposed deposits have been swept away, leaving it as a rocky mail protecting the limestones below. And this office assigned it in the economy, so to speak, of the mountain, where it in places apparently constitutes the deposit overlying the Carboniferous limestones, together with its striking lithological resemblance, renders the determination of its real stratigraphical relations a matter of unusual interest and importance. So far as we have been able, in the course of hastily-executed examinations, to study the true "red bed" series in localities where it exhibits what may be regarded as its typical development, as well as the subjacent deposits, it has been found to present an entirely different association of features, the consideration of which forms so important a subject of inquiry in the deposits under consideration.

At the extreme southern end of Téton Range the section of these beds in the crest of Station XLIII ridge, given in a preceding page, is sufficient, it would appear, to dispel any doubts raised on lithological resemblances of the actual relations of these beds. We here find intercalated with the red arenaceous shales and ferruginous sandstones layers of limestone which contain the relics of a Carboniferous fauna. And these fossils are not of the types of the latest period or epoch of the series, but are of not later date than the Coal-Measures, if, indeed, they prove not to be identical with Lower Carboniferous forms. The limestones of the latter, which here immediately underlie these passage beds, are charged with corals and other fossils of eminently Lower Carboniferous

types, as understood at the present time. Indeed, these upper beds recall the Saint Louis formation from the abundant prevalence of the coral *Lithostrotion* in them. These distinctively red passage beds are succeeded by a heavy series of reddish-tinged buff, fragmentary, siliceous deposits and limestones, which bridge over the Téton Pass and the mountain side to the west, and are finally succeeded by the Triassic "red-beds" within the disturbed belt of the Snake River Range to the southwest. The Gros Ventre Mountains and Buffalo Fork Peak show much the same materials in this horizon, so far as time permitted of ascertainment. To the west and southwest, however, this particular horizon was not recognized, if it there exists.

The principal stratigraphical peculiarities of the Upper Carboniferous series, exclusive of the extreme upper or Permo-Carboniferous horizons, consist of alternations of heavy beds of brittle, buff, siliceous material, or buff, reddish-tinged, laminated sandstones, usually quartzitic, gray to drab, siliceous or cherty, sometimes spar-seamed limestones, and variegated shales, which may reach a thickness of from 1,000 to 2,000 feet. The siliceous deposits predominate, but, owing to their fragmentary nature, their outcrop is usually strewn with the fine, angular *débris* derived from the breaking up of their own beds, except where the ledges are steeply tilted, when they are weathered into exceedingly craggy crests or hog-back ridges. These siliceous beds have afforded no fossils, except fucoidal-like markings. The limestones, however, afford fossils, which, as has been pointed out in preceding pages, present Upper Carboniferous facies.

In the Blackfoot Range these deposits show a thickness probably as great as that of the inferior limestones. Its limestone layers contain, amongst a group of fossils which, in the present state of knowledge, might not be regarded as of great value in the definition of epochal formations, a few forms that are regarded as characteristic of the Upper Carboniferous or Coal-Measure period. Such are the *Athyris subtilita* and *Productus longispinus*, which are associated with *Productus semireticulatus* (?) *Hemipronites*, minute crinoidal columns, Zaphrentoid corals, and a delicate form of *Syringopora*. On the northeast flank of the Caribou Range, limestones which hold apparently the same relative position are crowded with crinoidal columns, *Ptilodictya*, *Fenestella*, *Spirifer*, *Productus*, and a small *Platyceras* undistinguishable from a form, originally described by Mr. Meek, from the Upper Coal Measures of Nebraska, and which has subsequently been identified by Dr. White in collections from Carboniferous rocks near Santa Fé.

East of the Mount Putnam ridge the sedimentary strata form a shallow synclinal, in the eastern border of which occurs a heavy series of siliceous beds and quartzitic sandstones, interbedded with bands of limestone, which, although not with certainty identified with the Upper Carboniferous, hold a position inferior to the Jurassic deposits, which latter occur in the low ridge along the axis of the synclinal. It is possible that these upper siliceous horizons include Permian or Permo-Carboniferous beds. But to the north, in the continuation of the same ridge at Station V, Higham's Peak, the partially magnesian limestone layers associated with the siliceous deposits, which latter are here tilted into vertical position, traces of an interesting fossil fauna were observed, consisting of *Myalina*, *Aviculopecten*, *Spirifer*, and crinoidal remains, which certainly recall the faunal phases of high Upper Coal-Measure deposits in the country bordering the Lower Missouri in Iowa, Kansas, and Nebraska. But at this locality the strata are in so disturbed a condition as to render their satisfactory study an undertaking of some difficulty.

Apparently the same set of limestone and siliceous strata prevails in the Gros Ventre and Buffalo Fork Mountains, but time did not permit of more detail examinations beyond recognizing their general similarity to synchronous deposits in other parts of the district.

Permo-Carboniferous.—The discovery of Permian or Permo-Carboniferous horizons in the Rocky Mountain region, and in the great plateau to the west, was announced now several years since, and their occurrence in this more northern quarter is no more than might have been anticipated, however interesting the fact.

As already mentioned, in the low divide next east of Mount Putnam occurs a rather heavy ledge of limestone, overlying white and buff sandstones and arenaceous shaly deposits, which was found to contain a meagre fauna resembling, so far as the imperfect preservation of the specimens enables the determination of their generic and specific affinities, forms prevalent in Permo-Carboniferous horizons. These consist of a little coral, like *Stenopora* or *Chætetes*, a small *Pleurophorus* (?), a medium-sized *Schizodus* (?), and an obscure shell, which may belong to *Athyris*. The stratum in which the above fossils occur is overlaid by a heavy series of generally buff-gray, sometimes reddish, hard sandstones, with intercalated thin layers of limestone, in which no fossils were detected; and this is in turn succeeded by Jurassic beds containing characteristic fossils. The deposit holding the above-mentioned fossils would, therefore, on stratigraphical grounds alone, be referred to the Upper Carboniferous, while the apparent affinities of the fossils themselves strongly favors their reference to the latest epoch of the period.

The narrow belt of Palæozoic that fringes the northeastern flank of the Caribou Range, at one place between Fall and Pyramid Creeks, reveals an interesting exposure of the uppermost horizons of the Carboniferous. We here meet with associations of fossils, *Pleurophorus* and other Lamellibranchiate shells, which possess a peculiarly Permo-Carboniferous facies. The beds containing the fossils belong to a heavy series of limestones and sandstones several hundred feet in thickness, and which somewhat contrast with equivalent horizons in other parts of the district, as will be apparent from a comparison of the sections of these beds to which reference has been made in preceding chapters on local geology; but this may be due to the particularly clear exposure of the strata at the present locality, while elsewhere, with rare exceptions, they are much obscured by detrital accumulations in the surface. These Permo-Carboniferous deposits abruptly cease in a heavy bed of limestone, upon which rest the Triassic "red-beds;" while below they were preceded by limestones containing fossils which have been referred to the age of the Upper Coal Measures.

The northeastern belt in the Snake River Range exhibits another comparatively clear exposure of these deposits, where the stratigraphic details of their occurrence are varied to some extent, while paleontologically they offer the same distinctive features which characterize the horizon at other localities. But in this quarter, as in the Caribou Range, the uppermost deposit consists of a heavy bed of limestone, containing a small *Pleurophorus*-like shell, and *Lingula*, and which is immediately overlaid by the typical "red beds." The section in the vicinity of Station XL presents a fair view of the relative position of these deposits, which may include a thickness of 500 to 800 feet. In the Téton Mountains and eastern portion of the district it is not improbable similar deposits will be found to occur, although none were observed in that quarter the past season.

MESOZOIC AREAS.

From our present understanding of the occurrence of the various geological formations in the district, it is apparent that over its entire extent prevailed conditions favorable for the accumulation of groups of strata representative of one or more of the great periods into which the Mesozoic era was divided. Hence, in their distribution, the Mesozoic formations are generally found in one or other or both sides of the uplifted Palæozoic areas, where they occur in belts of greater or less extent, according to the varying conditions to which they have been subjected subsequent to their upheaval in the mountain borders. In the loftiest mountain elevations, as in the Téton Range, denudation has effected their almost total removal, limiting their occurrence to zones low in the outlying flanks, where they are in many instances completely hidden from sight by eruptive and detrital accumulations. But besides these areas, there are also perhaps still more extensive belts which may almost be regarded as isolated, forming the bulk of mountain ridges, as instanced in the Caribou Range, where the Mesozoic beds together with still more recent formations have been thrown into a most extraordinary series of flexures and folds. In the following pages brief mention is made of the present distribution of the various areas in which rocks of this era occur, and the more or less local aspects under which the component formations appear within the district.

Toward the south end of the Blackfoot Range, on the southwest flank, a limited exposure of Jurassic is found, which impinges on the Carboniferous rocks in the mountain ridge in a position such as leads to the conclusion that the strata are faulted, the Jurassic beds being a remnant of the west-side downthrow. A series of low secondary ridges south of the Blackfoot Range, at Stations XII and XIII, are made up of well-defined Jurassic beds which have been upraised into a symmetrical anticlinal, beyond which occurs a much more complicated belt occupying the space intervening between these ridges and a higher outlying Carboniferous ridge on the north. The same series of strata reappear on the southwest side of the Blackfoot on the extreme southern border of the district, but soon disappear beneath the Pliocene and volcanic deposits, which latter occupy a broad belt on the eastern flank of the low ridge extending south from Higham's Peak. In the latter divide the Mesozoics, Jurassic, and possibly Triassic, form the axis of a synclinal, which to the south also nearly corresponds to the water-divide of the Ross Fork-Portneuf and Blackfoot drainage. The end of the ridge on the west side of Lincoln Creek, according to Professor Bradley, shows a heavy plating of the same series. On the eastern side of this synclinal, the strata were involved in tremendous disturbance, the Carboniferous standing in vertical ledges, and the Jurassic also showing very irregular and variable dips, as though two distinct sets of disturbing forces had here met, throwing the strata into greatest confusion.

In the before-mentioned areas, where these rocks are in intimate association with Palæozoic areas, interesting examples are met with in the low ridges west of John Gray's Lake, showing a heavy series of strata, probably including both Triassic and Jurassic deposits, which seem to partially fold round their extremities, the nucleal rocks consisting of Carboniferous deposits. In the Caribou Range the same deposits appear in two or three anticlinal folds, in places inverted and possibly faulted, the direction of the forces concerned in the disturbance very nearly corresponding with that of the present mountain range. The middle por-

tion of the Snake River Range is occupied by a much disturbed belt, in which rocks of the age of the Triassic and Jurassic take a prominent part. Their position in that part of the range visited is upon the southwest flank of a faulted anticlinal, the beds dipping into a rather wide depression intervening between the two Carboniferous belts on the northeast and southwest borders of the range, and which is filled with softer and more recent deposits, probably of the early Cenozoic. But to the southeast, in the neighborhood of the upper entrance to the Grand Cañon, apparently corresponding deposits are thrown into a series of sharp folds, as indicated by the observations on this region recorded by Professor Bradley. Only at the southern extremity have strata of Mesozoic age been detected in the Téton Range, where a remnant remains on the western flank descending into the valley of West Téton Pass Creek. But on the northern and southwestern flanks of the Gros Ventre Mountains a fine exhibition of these rocks is met with. Indeed, in the northern declivity of the range, to the east, Dr. Hayden, in 1860, discovered representative formations pertaining to all three of the Mesozoic periods, viz, Triassic, Jurassic, and Cretaceous. The same series of formations, at least the "red beds" of the Trias and probable Jurassic deposits, have been upraised on the flanks of the Buffalo Fork uplift, which they doubtless encompass in a belt of variable width. Professor Bradley notes a limited belt of probable Triassic sandstones and red beds in the northern extremity of the mountain ridge between Buffalo Fork and the main Snake River north of Jackson's Basin.

The rocks of this era in the region under consideration represent its three periods, a generalized section of which is given below:

General section of Mesozoic formations in the Téton district.

MESOZOIC.	CRETACEOUS.	Sandstones, limestones, arenaceous marls, and indurated clays, underlaid by drab or ash-colored laminated marls and fine sandstone, with lignitic horizons; 300 feet and more. Dr. Hayden.
	JURASSIC.	Limestones, indurated calcareous shales, variegated clays, and sandstones; 1,000 to 2,500 feet.
	TRIASSIC.	Deep-red arenaceous shales, with drab clays, thin limestone layers, and heavy beds of red, sometimes buff, sandstones; 1,000 feet and less, to 2,500 feet or more.

TRIASSIC.

The "red bed" or Triassic series is well developed in most parts of the district where the strata of this period have been brought to view by upheaval and denudation. But, largely owing to the prevalence of shaly matter in their composition, at only few localities are they at all well exposed. In the southwest it would appear doubtful whether these deposits attain anything like their normal development, at least under the typical lithological phases which so uniformly distinguish the horizon to the east. In the vicinity of Fort Hall a heavy series of supra-Carboniferous and infra-Jurassic siliceous and calcareous deposits constitute a large share of the strata making up the divide ridge between Ross Fork and the Blackfoot, northeast of Mount Putnam, the relative position of which corresponds to that of the Trias. But if we are to

include in the latter the deposits here referred to, which embrace a thickness of about 2,000 feet, the depositions of the period underwent marked change in their lithological appearance and the nature of the components—indeed to such an extent as to render the term *red beds* of no descriptive significance in this quarter. The appearance presented by the horizon here alluded to is shown in the section across this ridge at a point but a short distance north of our southern boundary, a description of which has been given in a preceding page.

A few miles to the north, however, in the vicinity of Station IV, there occurs a set of red sandstone strata and deep-red arenaceous shales, underlaid by a heavy ledge of coarse, conglomeritic, quartzitic red sandstone, which, lithologically, bears marked resemblance to portions of the "red bed" series. But the details of the structural complications accompanying these deposits at the latter locality have not been sufficiently investigated to warrant a more definite statement of their stratigraphical relations than that based upon lithological resemblances. And, so far as lithological appearances may be relied upon, the reddish sandstones to the southwest and northwest of Higham's Peak (Station V) might be compared with the Triassic "red beds," only these deposits occur outside of and apparently overlying a belt of limestones whose fossils are probably allied to Jurassic forms. Hence, in regard to the horizons of this period in the southwest portion of the district, I can speak with any degree of confidence only of the section above mentioned, which crosses this ridge near our south line, and where the "red beds," as such, are scarcely recognizable lithologically.

The examinations in these deposits in the basin ridges west of John Gray's Lake merely recognized their presence as heavy beds of red sandstones and sandy shales, while in the vicinity of the Blackfoot Range only remnants of the formation were met with. But in the Caribou Range the Triassic deposits are developed under their ordinary phases, and, as seen along the northeast flank of the range, they may attain an average thickness. In this quarter it was found to be in many instances difficult to distinguish between these deposits and a series of red sandstones and shales which belong to a later formation, overlying or interbedded with limestones containing Jurassic fossils. Such is the case in the mountain block between Fall Creek and Pyramid Creek, and, unless these deposits reach an enormous vertical thickness at this locality, it may be questioned whether the red sandstone forming the crest of Station XXV ridge is not a member of the Jurassic rather than of the Trias. To the northwest of the latter point the space occupied by these deposits probably does not exceed 1,500 feet, and it may not be above 1,000 feet. Above the latter locality the Trias gradually declines in the present mountain border, being confined to a narrow strip adjacent the valley and not well exposed at the points visited south of McCoy Creek; this, of course, assuming that the rusty-red sandstones and shales and intercalated limestones at the latter locality and vicinity pertain to the Jurassic. Rocks of this age were not recognized in the wider belt extending over across to the southwest base of the range at any part within our territory.

The Trias is much more prominently displayed in the Snake River Range, and may be traced for miles by its color characters, its outcrop forming a narrow belt of variable width, extending from the Pierre's Mountains in the northwest to the low mountains south of Téton Pass, whence they probably extend down to the Snake River in the vicinity of the upper entrance to the Grand Cañon. In the immediate vicinity of Station XL this horizon is well exposed, consisting of heavy deposits

of deep-red arenaceous shales and harder sandstone beds, with a single limestone stratum observed, approximating a total thickness of 2,500 feet. The deep-red shaly deposits also include layers of drab-colored shales. The sandstones are gray or rusty buff to brown weathered and light red in color, in one of the lower layers of which occur very indistinct bodies which resemble medium-sized ovoid lamellibranchiate shells, but too imperfect for determination. These deposits are included between a limestone holding fossils of a Permo-Carboniferous facies below and a ledge of grayish-drab limestone with Jurassic forms above. Elsewhere in this mountain range, as in the vicinity of Téton Pass, horizons show deep-red sandstones and shales. The structural accompaniments in this region, as also the probable distribution of the same deposits in belts occurring to the southwest, have already been alluded to in the notice of the observations made in the Snake River Range.

The last above-mentioned series of "red-bed" exposures, according to Professor Bradley, reappear to the east of the Snake in the mountainous belts outflanking the Gros Ventre Range on the southwest; and along the northern flank of the latter range and in the Gros Ventre Valley they constitute a heavy series, including a bed of gypsum. Their occurrence in the vicinity of the Buffalo Fork uplift is, so far as could be made out, accompanied by a typical representation of the series.

JURASSIC.

It is difficult to assign to this member of the Mesozoic age a set of stratigraphical characters typical of its occurrence in all portions of the district. In the southwestern section, where the Jurassic strata constitute an important series in the low mountain folds either side of the Blackfoot, showing a thickness of a couple of thousand feet, more or less, the lower portion is made up of gray and drab limestones, sometimes magnesian and in places cherty, interbedded with chocolate-colored partially indurated shales and occasional layers of reddish sandstone, the upper portion showing several layers of gray chocolate or rusty weathered, sometimes arenaceous limestones, with drab and chocolate-colored shales and indurated argillo-arenaceous beds. This is essentially the stratigraphical structure of the formation or that portion of it exposed in the low divide between the Blackfoot and Ross Fork-Lincoln drainages. At the latter locality, the upper limestones are quite fossiliferous, being charged with *Aviculopecten*, *Pseudomonotis*, *Camptonectes*, *Myacites*, *Pholodomya*, and other Lamellibranchiates; the lower beds preserving only comminuted fragments of fossils, although elsewhere these beds afford fragments of *Pentacrinites* and a small *Gryphœa*(?), &c. However, in a single stratum low in the series a few obscure fossils, in the condition of casts, were met with including *Aviculopecten*(?) and two or three other small Lamellibranchiate shells, *Dentalium*(?) and a minute Gasteropod like *Viviparus*.

The same series of upper beds also appears in the low ridges east of the Blackfoot, at Stations XII and XIII. At the latter locality these well-marked Jurassic limestones are succeeded on the north by a series of gray limestones, reddish quartzitic sandstones, and red shales, occupying a belt about a mile across, reaching over to the Carboniferous ridge, the complicated structural features of which are very obscure and were not satisfactorily made out; but these limestones were found to contain at one point an obscure Lamellibranchiate resembling *Aviculopecten*, and at another place the fragmentary remains of what appear to be *Ceratites*. Of the latter, during the past season, Dr. Peale dis-

covered and brought in from the region south of this a beautiful collection, including several species of this genus; but at the present locality this *Ceratites* limestone and associated beds are in so confused a state as to render their relations either to the well-determined Jurassic on the one hand, and the equally characteristically marked Upper Carboniferous on the other, a subject of much perplexity. However, the *Ceratites* bed unquestionably overlies the Upper Carboniferous, between the siliceous beds of which and this particular horizon intervenes a space of between a quarter and half a mile across, in which obscurely exposed red-earth or arenaceous deposits occur. Hence, it would appear that the *Ceratites* bed probably occurs at the base of the Jurassic, though it may possibly pertain to the upper portion of the Trias, to which the red arenaceous deposits probably belong. A few miles due west of this locality, where the same or inferior limestones of the Jura are pretty well exposed, in the often-mentioned ridge west of the Blackfoot, the occurrence of *Ceratites*, if they exist in these beds, was overlooked; but in the outlying belt on the east flank of the Carboniferous ridge south of John Gray's Lake, just over our southern border, fragments of similar gray limestone were observed, but not *in situ*, which abounded in these interesting fossils. At the latter locality apparently a heavy series of red arenaceous deposits, comparable with the Triassic "red beds," fills the space intervening between the Carboniferous ridge and the low ridge in the crest of which the *Ceratites* limestone *débris* was found. The two above localities were the only places where this rock was observed within our district, and I have mentioned all the facts elicited in relation to its occurrence in order, if possible, to contribute something towards the data for establishing the stratigraphic position of the horizon.

The remnants of Jurassic strata elsewhere occurring in the Blackfoot Range afford little of interest in this special connection.

To the northeast in the mountainous belt of the Caribou Range the Jurassic deposits enter largely into the stratigraphic structure of a system of folds, which are finely displayed in some of the deeper cañons crossing the range transverse to the direction of the folds, which determined that also of the mountain range. On the northeast flank of the northern part of the range these deposits reach a thickness of 2,000 to 3,000 feet, but neither above nor below could the exact limits of the series be satisfactorily determined. It consists of limestones, drab and variegated shales, and indurated calcareous shales, with occasional horizons of brownish and reddish sandstones. A fair understanding of the deposits in this quarter may be gathered from the section through Station XXIV. The Jurassic limestones and shales at this locality are overlaid by a heavy ledge or ledges of quartzitic sandstone, beyond which, in successive superimposed positions, occur heavy beds of red arenaceous materials and drab indurated calcareous deposits, which appear to be conformable with the older formations.

To the southeastward much the same series of deposits were encountered as far as our examinations were carried. But in the section here presented we in vain seek for the counterpart of certain horizons which perform so important part and are so well characterized, paleontologically and lithologically, in the southwestern areas of this formation. The distribution of the fossils would appear to be much more general, with fewer local faunæ, such as were found in the arenaceous limestones on Lincoln Creek. The forms most prevalent are a small *Ostrea* (?) and one or two forms of small Gasteropods, the specific affinities of the latter, owing to the indifferent state of preservation of the specimens, being indeterminable, although they may belong to *Viviparus*. However, there occur other

forms of Lamellibranchiates, and fragments of the columns of *Pentacrinites* in widely-separated horizons in the series; while there are layers, as at Station XXVII ridge, characterized by peculiar faunal assemblages. At the latter locality, a bed is thus charged with a beautiful little *Exogyra*, *Belemnites*, &c. The latter fossil was also met with in the vicinity of Station XX, in the northwestern part of the range. Along the western border of the range the Jurassic is succeeded by the Cenozoic(?) formations, which apparently constitute about a third of its bulk, although the same deposits occur in belts of greater or less extent farther east.

Perhaps one of the most interesting sections of the Jurassic met with during the season was that in the northeastern portion of the Snake River Range, in the vicinity of Station XL, a detail description of which is presented in a preceding page. In a thickness of about 1,500 feet there are two or three heavy beds of limestone, one of which forms the base of the formation, with heavy deposits of drab indurated calcareous shales, and variegated chocolate-red clay shales, the upper 500 feet being made up of grayish buff hard sandstones and sandy shales, capped by a heavy ledge of rusty brown and reddish conglomeritic sandstone, which has almost the compactness of quartzite. The latter deposit is succeeded by light-drab fragmentary limestones and variegated shales, which in turn are capped by a heavy ledge of reddish-buff, hard sandstone, the whole adding a thickness of 500 to 900 feet to the lower series, or a total of 2,400 feet.

No fossils were detected in the upper series of limestone strata, consequently its relation to the lower series cannot be more definitely stated than that it occupies a conformably superimposed position. But in the lower series of limestones and indurated calcareous deposits, we find an indubitable Jurassic fauna. The latter beds are crowded with individuals of a small *Gryphæa*, like *G. calceola*, and a small *Ostrea*(?) less numerous. The basis limestone affords the remains of *Pentacrinites*, a largish smooth Lamellibranchiate, resembling *Camptonectes*, and a small indeterminate Gasteropod.

The conglomeritic sandstone bears some resemblance to the heavy quartzitic sandstone capping the Jurassic limestone series in the vicinity of Station XXIV in the Caribou Range, 15 to 20 miles in a direct line to the southwest; and it will be recollected at that locality this sandstone horizon is also succeeded above by drab calcareous deposits. But at the latter locality the determinate Jurassic limestone series, with its associated shales and sandstones, attains a thickness more than a third greater, while it presents, in the character of the associated strata, a marked contrast to the lower series as it occurs immediately southwest of Station XL at the present locality. This belt of Jurassic may be traced to the southeast as far at least as Station XXXIX, and it will probably be found to extend quite to the Snake, south of the Téton Range. Remnants of Jurassic beds also occur in the debouchere of West Téton Pass Creek, and probably once reached high up on the Téton Range, lapping up on the southwest terminus, subsequent erosion, however, having removed them from the higher acclivities.

Along the western end of the Gros Ventre Range, in the region fronting Jackson's Basin, the Mesozoic formations have been entirely denuded. But on the north flank of the range Dr. Hayden noted the occurrence of Jurassic, constituting an outlying belt succeeding the Trias, but which erosion has reduced to very variable width on the mountain flank as compared with its appearance over less exposed situations. Beyond their probable occurrence in the Mesozoic belt surrounding the

Buffalo Fork Mountains, little was acquired relative to their detail-stratigraphy in that section.

CRETACEOUS.

The work of the past season in this district did not encounter rocks of the age of the Cretaceous, so far as may be judged from paleontological evidence. However, to the south of our southwestern section, in the contiguous district, Dr. Peale discovered beds pertaining to the Fox Hills Group, charged with a distinctive fauna; but the northern extension of the highlands, in which the latter Cretaceous deposits were found, exhibited no certain evidence of the existence of similar horizons. In the vicinity of Fort Hall, to the east and northeast, outflanking the Jurassic on the west, in the disturbed belt at the intersection of the Mount Putnam and the Stations IV and V displacements, occurs a rather heavy series of red sandstones which may possibly be synchronous with some formation of this period. But the evidence is unsatisfactory and wholly based on apparent superposition of these deposits to fossiliferous Jurassic limestones, the connection between which could not be traced. On the northern flank of the Gros Ventre Range, however, Dr. Hayden discovered Cretaceous strata with characteristic fossils, *Inoceramus*, *Ostrea*, *Pinna*, *Cardium*, &c., a condensation of which, as well as Dr. Hayden's notes on the same, is incorporated in a preceding page.

As to the later series of formations belonging to Cenozoic time, of which extensive and very varied exhibitions were found within the territory of this division, their further consideration in this connection is deferred until a future time, when it is hoped that, with more complete, or at least more extended, observation in the unvisited quarters of the district where these deposits are believed to take a conspicuous place among the later sedimentary formations, some connection may be traced by means of which we shall the better be able to understand the relations of these, perhaps, anomalous late Mesozoic and Cenozoic deposits with their appearance in better-known localities in the country farther south.

CHAPTER VI.

VOLCANIC ROCKS.—GENERAL CHARACTER AND DISTRIBUTION.

That series of rock formations which owes its origin to volcanic or other igneous action is both varied and extensively distributed over the district. As here referred to, it embraces none but the later eruptive materials, since it is by no means certain that the granites in this region are of the same origin. Yet in the Téton Mountains, where some of the most lofty heights are blocked out of granite, intrusions of trap-like material are found in nearly vertical fractures which separated the inclosing rocks along lines more or less transverse to the axis of upheaval. Such trapean dikes are conspicuously displayed on the south shoulder of Mount Hayden and in the huge bulk of Mount Moran. Vein formations traverse the Archæan rocks wherever they are exposed to view.

Eruptive and intrusive volcanics.—Of the purely eruptive and intrusive volcanics of later origin, we have fine examples in the gray hornblendic trachytes of Mount Bainbridge in the Caribou Range, and the little dike-ridge at Station XVII in Willow Creek Basin, a few miles to the northwest. No data were observed by which the age of the latter deposits might be fixed with accuracy; but hand-specimens that were brought from both these localities were recognized by Dr. Peale as having intimate relationship, in both their lithology and mineralogical constituents, with the hornblendic trachytes of the Elk Mountains of Colorado. These Mount Bainbridge intrusions are, however, very variable in their physical constitution, often masses of the rock assuming a schistose character suggesting their possible origin as fragments of the crystalline schists, which were entangled in the molten matter in its passage through the metamorphic horizons; but this would hardly seem to explain their appearance in the intrusive sheets separating the sedimentary beds, which often show this structure throughout, and which may in some way be due to the presence of mica as one of the components of the rock. The local and very variable aspects of the dike-like and intrusive masses in Mount Bainbridge and at Station XVII have already been noticed, as also the association, at the former locality, of auriferous lodes from which the placer-gold mined in that neighborhood was derived. We have, therefore, in these two observed localities, eruptive mountain masses precisely similar to the isolated mountain clusters that protrude in the great sedimentary plateau of the Colorado region of Western Colorado and contiguous regions of the neighboring Territories, which have been so well investigated in the progress of the survey in that quarter. The trend of the dike-like mass in Station XVII, which, extended southeast, almost exactly intersects Mount Bainbridge, strongly suggests the probable intimate relations of the at present isolated masses—the intervening basin plain being covered by the later flows of basaltic lava—though the eruptive matter may not have protruded to a uniform height over this extent, but it seems to have

burst out in local upheavals or the violent fracturing of the sedimentary deposits, which denudation has uncovered within a comparatively recent date. South of Mount Bainbridge the intrusive matter was not detected, while in Station XVII ridge it appears to have resulted in a local uplift accompanied by fracturing of the sedimentaries, which latter appear to fold round the northwest and southeast extremities of the uplift without break in their continuity.

The early flowed trachytic lavas.—We next come to a series of flowed volcanics which exhibit in their constitution, perhaps, the most variable features of any of the divisions belonging to this class of rocks. From their position, often high up on the mountain-sides, and even occupying their crests in places, dipping almost uniformly in the direction of pre-existing depressions of erosion, they are presumably amongst the earliest products of volcanic effusion which were poured out and overflowed a vast extent of country about the sources of the Columbia.

These deposits consist chiefly of trachytic materials, but which exhibit in their local occurrence great variety in physical constitution, as will have appeared from the notices of these rocks in the foregoing chapters on regional geology. However, it may be deemed permissible briefly to review the salient local features which these deposits assume in different portions of the district, in order that they may be the more readily compared with the observations of my colleagues in adjacent regions.

The farthest west exposures of these rocks observed by myself were on the western flank of the Blackfoot Range. Here they are found to occupy a sort of basin area intervening between the foot of the range and the high basaltic-capped barrier on the west through which Blackfoot River has excavated a cañon on its way out into the Snake plains. The rock consists of flag-like, brown, drab, and pale brick-red trachyte, portions of which have a mottled appearance from the presence of small light specks, and sometimes small amygdaloid cavities, and crowns three or four conical, rounded hills which descend to the westward. The rock usually weathers a pinkish color, and at one point the ledges seemed to have a very gentle inclination to the northeastward, or in the direction of the Blackfoot Range, from which they are separated by a narrow belt of rolling, grassy hills. In a high rounded summit, 7,200 feet above sea-level, about four miles little south of east of the above locality, and occupying a recess in the range opening to the southwest, occurs a heavy capping of brownish-red and drab trachyte, in heavy and thin slabs or layers, dipping gently northward. The heavy-bedded layers are rounded by atmospheric action, even weathering by exfoliation. Traces of similar deposits were observed to the southeast, but of scarcely more importance than to indicate the excessive denudation which these early volcanic flows have undergone in this region. In the northern portion of the range, a highish ridge connecting the east and west spur-branches of the range shows heavy ledges of a softish dark-brown and drab mottled, vesicular trachytic lava at an elevation of about 6,200 feet, which, though apparently *in situ*, is too obscurely exposed to show more than its general appearance. It occurs in large weather-abraded masses in a bench facing Blackfoot Peak, which latter lies about one and a half miles to the eastward. Similar and probably identical lava-flows were elsewhere encountered, sometimes associated in the vicinity of the ordinary trachytes, though at no place were the relations of these rocks clearly shown.

At the northern extremity of the Willow Creek Basin hills, a couple of miles north of Station XVI, a heavy bed of gray or bluish-drab, compact trachytic rock unconformably overlies Laramie Group deposits, in

a high summit, 7,200 feet, at this end of the highlands. The deposit, which evidently belongs to a heavy bed, is divided into uneven layers 2 to 12 inches or more in thickness, which ring under the hammer, and which dip 40° to the northeast, declining in the steep northeast slope of the hill, upon whose flanks rests a heavy mass of basaltic lava.

In the Caribou Range, to the northeast of the last above locality, some interesting exhibitions of the trachytic deposits were met with, but always occurring as isolated remnants of a formerly much more extensively distributed flow. Near and on the crest of Station XX ridge, a couple of miles north of the upper entrance to Fall Creek Cañon, occur more or less abraded masses of a rusty brown vesicular trachytic lava, with which are associated concretionary nodules of light-drab and black obsidian, fragments of the latter being abundant in the summit of the ridge. This rock both in its denuded outcrop and physical features resembles and is apparently identical with the above-mentioned vesicular volcanic ledges west of Blackfoot Peak. It appears to have partially metamorphosed the Jurassic shales with which it came in contact, although no satisfactory exposures of the rock were here seen *in situ*. It must, however, have overflowed the denuded and tilted Jurassic strata, yet the whole mountain ridge doubtless has been subjected to great erosion subsequent to the period of the flow, in which the latter indeed has suffered almost complete destruction. It was traced in the western declivity of the range at the head of Porcupine Creek, indicating the probable former connection of the at present isolated exposures. Also, in heights about four miles almost due north and northwest of Station XX, in the neighborhood respectively of Stations XXI and XXIV, and at Station XXIII, on either side of the narrow northern summit of the range, considerable plateau-like remnants of the same material are met with, the inclination being gently to the west, northwest, and north, off some of the highest elevations in this part of the range, 7,200 to 7,400 feet above tide. At the latter locality, Station XXIII, the bowlder-like masses are underlaid by a heavy deposit of conglomerate, the coarse materials consisting chiefly of more or less abraded fragments of quartzite and limestone, the cementing material resembling a variegated trachytic tuff, which in places greatly predominates, where it assumes much the appearance of the ordinary variegated trachytic materials, in color buff, reddish-chocolate mottled, drab to pink, and decomposing into a fine ashy soil. This deposit at one point dips at an angle of 25° to the northward in the direction of the low country in the debouchure of the Snake.

In the high plateau bench at the northern end of the Caribou Range, 6,800 feet, a considerable extent of the surface is based upon the drab and pink trachytic flow, which has a gentle inclination west of north. This deposit extends round the northern end of the range to the western flank, more or less interrupted by denudation, in which latter region it forms the coping of sloping plateaus which rise up out of the volcanic-floored upland of the Willow Creek Basin on the flank of the range to an elevation of 7,200 feet. Of the same character are the sloping table ridges southwest and west of Stations XXI and XXII, to the south of which they doubtless still occur over considerable areas and were once connected with the mass at the northern extremity of the basin ridges north of Station XVI.

In the Blackfoot Valley, near our southern border, similar pink-drab trachytes were found resting upon the soft Pliocene lake-beds. At Station XXX such an exposure occurs, dipping in the direction of the valley, northeast, at an angle of from 15° to 20°. At the latter

locality these deposits are intimately associated with brown basaltic lava, which latter also partakes in the disturbances that tilted the older trachytic flow, and which appear to have been gently folded over a broad, low ridge, whose axis lies in a northerly and southerly direction.

In the eastern border region of the great plain of the Snake these trachytic deposits occur under still more varied relations. Professor Bradley describes the general structural features of the extreme northern spur ridge of Mount Putnam, which terminates in the plain between Ross Fork and Lincoln Creek, as consisting of the light-colored Pliocene sandstones and limestones, interlaminated with sheets of "trachytic porphyries and coarse volcanic sandstones, all dipping about north 54° east, at angles varying from 15° to 30°." These deposits Professor Bradley found upraised in a rather sharp anticlinal fold, the southwestern flank of which shows steeply inclined basalts, dipping at an angle of 72°, S. 34° W. It would appear that the trachytic sheets here referred to were deposited by outflows during the period of deposition of the Pliocene beds, with which they have become regularly incorporated, rather than intrusions of igneous matter between the soft strata. Hence their relative age, and some notion of the volcanic phenomena accompanying the laying down of the strata during this latest period of the Tertiary, may be readily conceived.

Similar exhibitions of these early trachytic flows are also met with in the lower portion of the lower valley of the Snake, although they are, in the latter region, not so clearly associated with Pliocene beds as at the locality above mentioned, while, at the same time, in their intimate relations with alternations of basaltic lava and heavy beds of modern conglomeritic accumulations, they offer new and still more varied phases, which indicate the long continuance of these eruptions and the variety in their materials, approaching the later stages probably immediately preceding the grand eruptions which overflowed with molten lava and desolated a vast extent of the interior basin of the Pacific slope within a period so comparatively recent that it may truly be termed modern. These deposits have also been described as reclining on the flanks of the mountain borders of the valley, dipping at a moderate angle in the direction of the lower depression, but they appear not to have reached so high on the mountain summits as the before-mentioned and doubtless older deposits. About midway of the lower valley of the Snake, its whole breadth is choked by huge masses of trachyte and laminated porphyritic trachytes, associated with reddish-brown minutely vesicular basalt, which here seem to form the basis of the deposit, as though it had poured out of a vast fissure in the immediate neighborhood, inundating the valley. But above this point the valley has been so thoroughly swept out as to make it a matter of some doubt whether the volcanics ever extended far above Pyramid Creek, not a vestige of them having been noticed on either side of the valley.

In the region of the Téton Range, especially in the borders of Pierre's Basin, the earlier volcanics exist on a far grander scale. They also present a marked physical change as compared with the flows holding similar position in the region above briefly noticed, reaching up on the western flank of the Téton Range, to the north, to an elevation of above 8,000 feet, but declining to the south, where, however, they have suffered extensive erosion and have been entirely removed from the opposed flank of the Snake River Range, until reaching the northeastern extremity, where they occur in gently uplifted benches, precisely like the great volcanic foreland on the west flank of the Téton Range. These flows once filled the entire area of Pierre's Basin, indeed they probably or

possibly constitute the floor upon which the later quaternary detritus of the present basin surface rests; but they are accessible for satisfactory study only at comparatively few points, as the majority of the exposures south of Leigh's Creek, on the east side, and Horse Creek, on the west side, are mere remnants, and these much obscured by late weather action. But in the cañon of the North Fork of Pierre's River, where it descends the great foreland, these deposits are exhibited in magnificent sections, miles in linear extent, and revealing a vertical thickness of several hundred feet. This foreland seems to be made up of several distinct benches of different volcanic products, which higher on the mountain side decline at a rate a little greater than the descent of the stream, so that, in passing from the mountain to the plain, successively higher flows are met with. At the head of the North Fork the earliest flowed material is in contact with Silurian and Carboniferous deposits, the steep bluff face here showing the lower masses of rusty, coarse-vesicular trachytic lava, with obsidian, which is so like the remnants before noticed in the northern summits of the Caribou Range that their identity can hardly be questioned. This ledge is underlaid by decomposing porphyritic obsidian trachytes having a burned-out appearance in places, whose coarse sand *débris* litters the steep talus slopes. The obsidian, occurring in fragments here as elsewhere, contains little globules of spherulite; but these lower beds are so obscured by the action of the weather, which has covered them with a mantle of their own detritus, as to conceal the point of contact with the sedimentaries as well as the inferior portion of their own ledges, which more extended search than we were able to bestow will doubtless yet bring to light. But no evidence of the peculiar semi-fragmental volcanic deposits, such as apparently constitute the basis of these early volcanic flows in the summit region of the Caribou Mountains, was observed. These deposits once, doubtless, reached high up on the mountain-side in the vicinity of Station XXXII, but at a period before the North Fork had begun to excavate its cañon, in the process of which not only the volcanics, but a vast amount of sedimentaries also, were swept away and mingled with the finely-comminuted soil which spreads a mantle of fertility over the undulating uplands which stretch far out into the great plain. South of the North Fork these same volcanics reach well up on the ancient denuded Archæan mountain flank, and still farther in the same direction they exist as mere remnants of the rusty porphyritic and pink and drab trachytes, always inclining toward the basin. However advanced erosion had progressed in leveling the great range prior to the effusions of the igneous matter, much of the more conspicuous effects of erosion that strike the observer to-day, such as the gorges which cut the great foreland, have been executed subsequent to the volcanic emissions. If the cañon-valleys reached their present depth prior to the volcanic flow, which seems very doubtful, they have been entirely cleaned out and their beds filled with the *débris* swept down from the interior portion of the range. This is apparent from an examination of any of the cañon mouths south of Bear Creek.

Descending the foreland either side of the North Fork of Pierre's River, the earlier volcanic flow is succeeded above by successively more recent flows, which present considerable variety in physical appearance. Throughout the cañon a heavy mass of laminated perphyritic trachyte prevails, extending to the junction of Pierre's River, and doubtless below that point, and which has a peculiar style of weathering, generally in parallel planes, simulating the deposition planes of sedimentary deposits. Portions, in the upper part of this laminated mass, are, however,

quite heavy bedded, and, as seen in great blocks rounded by the action of the weather, it is sometimes coarsely vesicular, recalling the porphyritic obsidian trachytes which form the basis of the flows. The laminated ledges are weathered into the most varied and picturesque monumental shapes all along the precipitous cañon sides, where the exposures frequently reach a height of 200 or 300 feet, perhaps more, above the bed of the stream. They are overlaid by the thin-bedded, pink and drab trachyte, with disseminated feldspar and sanidine, which in places show a thickness of above 40 feet. In the laminated ledges, at the point of contact with the trachyte, undulations in the surface are observed, like nonconformities or wedge-shaped masses, such as are not infrequent in deposits of purely aqueous deposition. And in the prairie upland masses of dark vesicular basaltic lava are encountered overlying the trachyte, and which, physically, are undistinguishable from the basalts which overspread the lower level of the Snake plain. But the connection between the basalts of the upland and those of the plain is not so apparent, denudation having effected changes in the surface since the flow of these materials which will require careful research in order to discover their true relations. It should also be observed that the basaltic ledges were found in positions indicating that the trachyte had been eroded prior to the flow of the basalt, which latter occurs at levels scooped out of the laminated porphyritic deposits. Erratic-like masses of steel-gray, intensely hard basalt are met with in the foreland slope west of Station XXXIII, though no regular ledges were observed in this position. At this point, in the east-facing bluff slopes of one of the foreland benches, the same series of volcanics is shown that was noticed in the vicinity of the confluence of the North Fork and Pierre's River; that is, the laminated porphyritic trachytes, overlaid by the pink and drab ledges, and in the surface large masses of the tough, dark, bluish-green basalt, which weather by exfoliation; the ledges having been upraised a thousand feet above their position at the latter locality in a distance of 10 miles. All the above volcanic ledges extend south as far as the upland divide between Cañon and Leigh's Creeks, beyond which the basalt appears not to extend, and the inferior deposits have been much attenuated by erosion.

Similar pink, rusty-weathered trachytic ledges rise up in great benches around the northern end of the Snake River Range, attaining about the same height as in the Téton Range, about 8,000 feet, or between 2,000 and 3,000 feet above the general level of Pierre's Basin. Towards the lower level of the Snake Plain, to the north, heavy outliers of pink trachyte are met with, forming low bluffs a hundred feet in height along the edge of the upland, where it is skirted by Fall River, or the Middle Fork of Henry's Fork, below the mouth of Conant Creek. At the latter locality, which was also visited by Professor Bradley, the ledges are much disturbed, dipping from vertical 75° northeast, and at another point 60° southwest. The cleavage structure gives the mass a thin-bedded appearance. This rock extends several miles along the stream above, and, rising the grassy uplands between Conant Creek and North Fork of Pierre's River, similar ledges appear in the declivities, generally in narrow outcrops running in a southeasterly direction; the exposures, however, not showing marked disturbance. A rather high ridge in the midst of this upland is reported by Professor Bradley as marking the "rim of an old broken-down crater, which faces nearly due east. The lava is a laminated mixture of quartz, obsidian, and feldspar; but no masses seemed to be *in situ*, so that direction of structure could not be determined."

The laminated porphyritic trachyte reaches a short distance up the valley of West Téton Pass Creek; but it is seen here only in remnants, and takes no conspicuous part in the formation of the topographic features of this part of the basin. But, passing over the ridge at the south end of the Téton Range, on gaining Jackson's Basin, almost opposite the mouth of East Pass Creek, Professor Bradley found a heavy mass of porphyritic breccias, "much distorted, but having a general northwesterly dip," around which the sedimentaries are clustered, forming the Lower Gros Ventre Buttes.

It appears that the tilting of these volcanic ledges agrees with the dip of the loose deposits of the late Tertiary in their immediate vicinity, and was probably determined by the same disturbances. To the north, at the southern end of Jackson's Lake, Professor Bradley observed "high knobs of porphyries and trachytes," and opposite, at the extreme western foot of the highlands outflanking Mount Leidy, a detached mass of dark-green porphyritic lava caps a low ridge on the south side of Elkhorn Creek, dipping 15° to 20° northwestward. It is not improbable other remnants of a similar character will be found to the north, connecting those above noticed with the great volcanic plateau of the lake region, which Professor Bradley observed to be largely composed of "porphyries and trachytes, with porphyritic obsidian"; and through the plateau deposits we may reasonably infer thence unbroken continuity with the laminated porphyritic deposits which reach up on the west flank of the Téton Range.

Professor Bradley has already noted the occurrence of porphyritic trachytes on the northern or eastern slope of the divide descending to the upper valley of the main Snake, where they cap the ridge, which is based upon Mesozoic and Palæozoic deposits, the volcanics dipping 30° southwest, or a little less than the inclination of the sedimentary beds which outcrop in the western flank of the ridge, opposite and below the mouth of Lake Fork. But to the east the volcanics appear to change, being made up of "rapidly-disintegrating volcanic rocks, mostly conglomerates of trachytic porphyry, obsidian," &c., with upthrusts of "gray trachytic lavas and red basalt, partly vesicular, though mostly compact," which Professor Bradley observed in high ridges about the sources of the Snake, at an altitude of about 9,600 feet. The southern side of this divide, descending to the lower course of Buffalo Fork, shows no volcanics, at any rate none were observed during the present season's work in that neighborhood, unless the remarkable bowlder-deposit that extends in the summits northeast from Station XLVIII are partly ascribable to volcanic origin.

Basaltic lava flows.—Next in order of chronological sequence we have briefly to notice the great basaltic flows which occupy so immense an area in this region, indeed nearly all the upland basins in the country west of the Caribou Range, and spreading out over nearly the entire area of the great plains of the Snake. The physical characters of these deposits in the plains region have already been so much discussed, that only such facts are here presented as were observed in the upland region, which may contribute a moiety to our knowledge of their distribution and something on the associated phenomena here encountered.

Along the eastern border of the Snake plain the basalts have been uplifted to a position several hundred feet above their level in the plain, and throughout the lower valley of the Blackfoot they exhibit marked disturbance, being elevated into low folds, one of which appears to have great persistency, following nearly the course of the Blackfoot between its northern bend where it cuts across the western declivity and the

southern border of our district in the vicinity of Station XXX. North of the Blackfoot, these basaltic flows are gently upraised in the long grassy foreland flanking the Blackfoot Range, forming low benches remarkable for their uniformity of slope. The entire area of the plains portion of the Willow Creek-Blackfoot Basin is floored with these deposits. To the south they do not appear ever to have reached very high on the flanks of the Blackfoot Range, where their elevation is near 7,000 feet, or 1,400 feet higher than the bluff faces of the sloping benches at the northern end of the range. Hence, it would appear that the basalts have been little if at all disturbed by elevatory forces situate in this range, from which we may infer that in the latter mountain belt no movement has taken place subsequent to the later outpouring of the igneous matter which envelopes their base, and whose apparent inclination was merely the result of the partly fluid mass flowing over pre-existing gentle slopes toward the lower levels of the Snake Basin. But in the basin region east of the Blackfoot Range, the basalts rise up into a prominent ridge between Willow and John Gray's Creeks, in the rugged crest of which they occur a thousand feet above the adjacent plain. At Station XIV, which occupies one of the culminating points of this ridge, 7,400 feet, the basalts gently rise up into the summit, the north and east face of which has been broken down by denudation in precipitous walls. The broad, rounded summit of the mountain is strewn with scoriaceous lava, while in the immediate vicinity much of the compacter and slag-like material has a very recent appearance, merging into the ordinary dark steel-gray and brown basalt of the slopes and basin plain. Although it might be difficult at the present day to define its limits, it seems very probable that this locality marks the site of a crater-vent from which issued the matter covering the declivities. This ridge is based upon Mesozoic or Tertiary formations, whose folding undoubtedly took place prior to the earliest of the volcanic flows, and which to the north, in the vicinity of Stations XV and XVI, have been entirely denuded of the igneous mantle, a remnant of which, however, forms the cap of XV, dipping gently to the westward into the basin level.

As has previously been mentioned, in the northern extremity of this ridge the sedimentary beds pass beneath a heavy sheet of trachyte, which dips at an angle of 40° to the northeast. The question arises, What are the relations of the various volcanic flows here met with to the dynamical agencies concerned in the uplifting of the sedimentary deposits which constitute the nucleus of the ridge? Subsequent to the flow of the trachtye the ridge was extensively denuded, baring the sedimentaries upon which the later flow of basaltic lava rests in immediate contact. Hence the inclined position of the trachyte, if not attributable to late-continued elevatory forces seated within the ridge, might be explained by referring its source to the same volcanic vent from which was poured the basaltic material; but between the two flows there must have elapsed an interval of time sufficient to allow the almost total degradation of the earlier flow, of which the tilted ledge in the northern slope of the ridge is evidently but a remnant of a formerly extensive deposit, which may indeed have covered the whole country roundabout with a sheet of trachyte continuous with remnants elsewhere occurring. But this explanation may not satisfactorily accord with all the facts, meagre as they are. In a former page reference was made to the occurrence of an upthrust of hornblendic trachyte which marks, if it did not determine, the axis of a lower parallel ridge to the east between the forks of John Gray's Creek. This upthrust trends about W. 40° N. and E. 40° S., and although the effects of displacement at-

tributable to it diminish in either direction from the culminating point, if the line of uplift be extended it exactly intersects the hill whose northeast flank is plated by the trachytic flow above mentioned. This naturally suggests the query, Was not the uplifting of the trachyte in part, at least, due to elevatory forces accompanying the upthrust of this dike-like mass of eruptive material? In the latter event, we would be enabled to determine with precision the relative date of the eruption of the hornblendic trachyte, which must have occurred at a period subsequent to the earlier trachytic flow, if indeed it was not also antedated by the basaltic flows.

In the basin ridges west of John Gray's Lake basaltic and scoriaceous lavas are gently upraised on their flanks. And so, also, around the northern extremity of the Caribou Range, where their position is apparently the exact counterpart of their relation to the Blackfoot Range, with which latter, indeed, they are continuous, forming the upland slopes intervening between the low mountain ridges and the Snake plain. This upland border region is deeply scored by the cañon-courses of the streams flowing out into the Snake, and the basalts of which it is made up extend well up into the lower valley of the Snake, which has cut a deep, narrow gorge, in places several hundred feet in depth, walled by the sombre, igneous ledges. To the north and northeast this upland gradually expands, and finally merges into the great volcanic plateau which stretches north from the northern extremity of the Téton Range, forming the water-divide west of the lake basin at the sources of the Snake. In the undulating slopes north of Pierre's Basin, and reaching up on the great volcanic foreland on the west flank of the Téton Range a thousand feet higher, evidence of the former general distribution of the basaltic flow over the whole extent of this upland region was not wanting. As has already been noticed, the basalts in this region were flowed over the denuded surfaces of the earlier trachytic flows. But how to account for their gently uplifted position on the flanks of the Téton and Snake River Ranges, no satisfactory data were gained, beyond the very natural supposition that their present position is the result either of late-continued elevatory movements situated in the mountain areas, or subsidence in the basin region; for no evidence was observed that would suggest the mountains themselves as the sources whence emanated the outflows which cover their lower declivities.

East of the Téton Range, in the region of Jackson's Basin, the basalts, if ever they existed, have been entirely swept away; indeed, erosion has been carried to such an extent in this basin up to a very recent date that only meagre remnants of the older volcanics are now to be met with. But passing east to the summit of the continental watershed, its level crest, southeast of Togwotee Pass, seems to be capped by a heavy flow of late lavas in the midst of which rises a low dome of scoriaceous and compacter lavas, which is, possibly, the remains of a crater. This outburst occupies the very summit of this part of the watershed between Togwotee and Warm Water Passes, at an altitude of 10,000 to 10,500 feet above the sea at Station LI. The dark lava and reddish to yellow scoriaceous matter is precisely like that occurring at before-mentioned localities supposed with some probability to mark the sites of crater-vents; and if the wall of dark basalt-like rock, which extends along the mountain crest several miles, or as far as could be seen, from a point a short distance northwest of Station LI, thence southwards, originated in matter thrown out from the same vent, little disturbance or change has taken place subsequent to the effusion, except that produced by the enormous erosion which has acted upon all these materials up to the present

time. However, this supposed basaltic or lava cap of the watershed perceptibly, though very gently, declines to the southwards. As I did not visit the ridge at this point, I am unable to state more fully its magnitude in a transverse direction; but it seems very probable that it merely forms a remnant strip, to the presence of which is due the preservation of this part of the great divide.

Encompassing the head of Buffalo Fork and its mountain tributaries, and constituting the watershed and a large extent of territory to the east, embracing the sources of the Yellowstone, and, according to Captain Jones, the headwaters of Gray Bull River, and reaching south along the continental divide nearly to the parallel of 43° 30′, occurs a vast accumulation of partially sedimented volcanics, the origin of which is almost beyond the comprehension. This mass is chiefly made up of volcanic breccias, with heavy layers of volcanic conglomerate, sands, and mud, the latter of which exhibit unmistakable indications of aqueous deposition, though the former usually shows an aggregation of angular fragments of various volcanic products, trachytes and basalts, held in a fine cement-matrix like trachyte-tuff, but which in the mass presents apparently regularly bedded structure-planes, which give to the exposures in the numerous mountain escarpments the sombre banded appearance by which these deposits may be recognized at great distances. In the region here alluded to they are slightly inclined in various directions, as though they had been subjected to some slight disturbance, at least, by elevatory movements located in more or less isolated areas of displacement, such as that in which the Buffalo Fork Peak uplift resulted which brought to view the crystalline basis rocks and the whole series of older sedimentaries of the region. Besides other disturbances in these deposits, referred to in the general description of this part of the district, in a preceding chapter, Togwotee Pass appears to occupy the axis of a very shallow depression in the volcanic strata which perceptibly, though gently rise to the northwest and south from the vicinity of this gap in the great watershed.

This deposit may attain in this region a thickness of 2,000 to 3,000 feet, possibly even a greater thickness. Entire mountain-ranges have been fashioned from its mass, including some of the loftiest and most rugged elevations in this region, while the effect of atmospheric erosion has produced the most wonderful and sublime mountain scenery. The observations of Dr. Hayden on the origin of this deposit are so comprehensive that I beg to quote the graphically expressed results of his own earlier investigations in this relation.* "The question arises in the mind, Whence originated this vast deposit of breccia or conglomerate, and what were the physical conditions under which the materials were deposited? As to their origin, we must conclude that they were thrown out by volcanoes into the surrounding waters much as similar materials are ejected from modern volcanoes at the present time. We find, however, that these breccias are of immense thickness, sometimes 4,000 to 5,000 feet, as at the sources of the East Fork and in the mountains at the head of the Yellowstone above the lake. Some of the highest mountains in the northwest are capped by these volcanic breccias, arranged in horizontal strata, and showing most clearly that the agent was water. In almost all cases the stratified breccias are perfectly horizontal from base to summit, thereby indicating the probability that there has been no important movement of the earth's crust since their deposition. We must conclude, then, that at a comparatively modern date the waters so covered these mountain-ranges of the northwest that not even the

* U. S. Geological Survey of the Territories, 1872, p. 38.

summits of the loftiest peaks were above the surface. It is barely possible that we might make an exception in the case of the Grand Tétons. We may suppose that the materials were supplied from the numberless volcanic fissures in unlimited quantities in a comparatively brief space of time; but the period which would be required for the waters to arrange this matter in the remarkably uniform and compact series of strata which we find at the present time must have been great. The results have been carried on upon such a stupendous scale that the mind finds with difficulty the courage to grapple with them or attempt to explain them. And then, subsequent to the deposition of these enormous beds of conglomerates, has been the wearing out of cañons and valleys 2,000 to 4,000 feet in depth, the sculpturing of some of the most marvellously grand and unique scenery on the continent."

The relative age of this vast accumulation, a measure of which may be sought in the character of its components, leads us to infer its comparatively recent date. The coarse materials which enter so largely into the composition of the stratified mass, especially noticeable in the conglomeritic portions, consist of fragments of all the older volcanic products, as trachytes and laminated porphyritic trachytes, while the more modern flows and eruptions have contributed fragments and bowlders of basalt and scoriaceous lava. The base of the deposit, its contact with older volcanic deposits and sedimentary formations, is so concealed by the immense talus accumulations which bury the foot of the mountain-walls, into which the deposit has been eroded, that we as yet possess few and perhaps no satisfactory facts exposing the character of the earliest stages of this remarkable deposit. In the approaches to Togwotee Pass huge outliers of exceedingly sombre, jagged breccia, apparently *in situ*, and in places disturbed or tilted from the original horizontal position, are met with at a level 1,500 to 2,000 feet or more below the neighboring mountain-summits, and which may indeed belong to the foundation of the deposit. The latter masses bear every appearance of intense volcanic action, as though their materials, rock fragments, sands, and mud, have passed through a fiery ordeal and been so rapidly ejected as not to allow their rearrangement by aqueous currents, but which latter performed so prominent a part in the redistribution of the later accessions to the great deposit.

REPORT OF A. C. PEALE, M. D., GEOLOGIST OF THE GREEN RIVER DIVISION.

LETTER OF TRANSMITTAL.

WASHINGTON, D. C., *December* 31, 1878.

SIR: I have the honor herewith to hand you my report on the geology of the district examined by the Green River Division during the field season of 1877. The party consisted of Mr. Henry Gannétt, topographer, directing; J. E. Mushbach, assistant topographer; F. M. Eastman, and myself, with two packers and a cook.

The district examined comprises 13,000 square miles. We began work on June 1, at Green River City, and left the field at Ogden, October 1, being in the field four months. Some portions of the districts were, therefore, necessarily more closely studied than others. It was my object to obtain a correct general idea of the region, knowing that the detailed investigation would have to be left for future study on account of the limited time at our disposal.

I have colored a provisional geological map. Before the final map is colored, several localities, in which the relations of the strata are somewhat obscure, must be visited, and a careful paleontological study must be made of several interesting fossil localities.

The district is divisible into three drainage areas, and to facilitate the comprehension of the description, the Descriptive Geology is given in three chapters corresponding to this division of the district. These chapters are necessarily mainly a transcript of the field notes. Preceding these chapters, in two others, I have given the general features and an itinerary. In the concluding chapter I have given a *résumé* of the geological features, presenting also such generalizations as are most obvious. The time allotted to the preparation of the report has been too short to enter into an extended discussion of the orographic problems that present themselves, and they will have to be deferred for the present.

For the illustrations accompanying the report I am largely indebted to Mr. W. H. Holmes and Mr. F. D. Owen, and the photographs of Mr. W. H. Jackson. The maps are due to the work of Mr. Henry Gannett. The topographical report of the latter supplements this, and will give all the topographical details, elevations, &c.

To my colleagues, both in the field and in the office, I am under obligations for their cordial co-operation in my work. I am especially indebted to Mr. J. E. Mushbach, to whose zeal and industry in the collection of fossils and other data, while in the field, is due the elucidation of a number of obscure points in the geological structure of the district.

To Captain Bainbridge, in command at Fort Hall, and to his colleague, Lieutenant Hall, we desire to express our thanks for the kindness shown us while we were refitting at their beautiful little post.

Hoping this report may meet all requirements, I have the honor to remain, very respectfully, your obedient servant,

A. C. PEALE.

Dr. F. V. HAYDEN,
United States Geologist-in-charge.

REPORT ON THE GEOLOGY OF THE GREEN RIVER DISTRICT.

By Dr. A. C. Peale.

CHAPTER I.

GENERAL INTRODUCTION.

AREA.

The district assigned the Green River Division for the season of 1877 lies between the meridians 109° 30′ and 112° and between the parallels 41° 45′ and 43°. This includes an area of about 11,100 square miles, the larger portion of which lies within the limits of Wyoming Territory, the rest being divided between Utah and Idaho. The area thus indicated was surveyed, and in addition to it a belt of country reaching west to meridian 112° 30′, so that the entire area surveyed amounts to 13,000 square miles, distributed among the three Territories as follows:

	Square miles.
Wyoming	6,562
Idaho	5,328
Utah	1,110
Total	13,000

On the east our work connected directly with that of the Sweetwater Division, under Mr. Chittenden and Dr. Endlich. Our northern line was the southern limit of the work of the Teton or Snake River Division, under Mr. Bechler and Mr. St. John. The country bordering our district on the south has been explored and mapped in detail by the Survey of the Fortieth Parallel, under the direction of Clarence King.

FORMER GEOLOGICAL EXPLORATION.

Although from the time of Bonneville's explorations to the present time the district has been traversed by many parties, little has been added to our knowledge of the country outside of their immediate routes of travel. This refers more particularly to the eastern and northern portions, for the western and southwestern parts of the district are comparatively well settled and therefore well known. Nearly all previous explorations were for the specific purpose of selecting routes for wagon-roads across the country, and the additions made to our knowledge were geographical and to a limited degree topographical rather than geological. This subject will, however, be referred to in more detail by Mr. Gannett in his report. The only geological explorations previously carried on in the district were of a reconnaissance character, and extended over but limited portions of the district. The explorations of the Geological Survey in in 1870, 1871, and 1872, comprises the largest portion of this reconnaissance work.

In 1870 Dr. Hayden passed near our eastern line on his way from South Pass to Fort Bridger, following down the Little and Big Sandy Rivers.*

* Report U. S. Geol. Surv. of Ter. for 1870, 1871, pp. 39–41.

In 1871 the survey travelled northward through Cache Valley and Marsh Creek and the Lower Portneuf Valley, in the western part of the district, *en route* to the Yellowstone National Park, and in the following autumn on returning from the field the party came through the Upper Portneuf Valley to the bend of Bear River, and thence via Bear River Valley and Bear Lake to Evanston, where the expedition disbanded.

Although the work done was somewhat general in its character it was essentially correct, and all that has been added during the season of 1877 is in the matter of detail and in tracing its geological connection with the formations of the surrounding country.

In 1872 the Snake River Division of the survey passed northward from Ogden via Malade Valley and the Portneuf to the Snake River plains. In 1872 also, Prof. E. D. Cope took a small party over the southwest corner of the Green River Basin, visiting Fontenelle Cañon. (See Report for 1872.)

In 1873 an expedition to the Yellowstone National Park under Capt. W. A. Jones went from Fort Bridger to Camp Stambaugh over the route via Big Sandy, &c., followed by Hayden in the reverse direction in 1870. Prof. Theo. B. Comstock acted as geologist for the party and has colored a geological map which includes the southwestern part of the Wind River Mountains and the adjacent portion of the Green River Basin. All that falls within the limits of our district is incorrectly colored, and the explanation is found in the fact that Professor Comstock never visited the portions thus colored. On the southwestern slopes of the Wind River Mountains formations from the Lower Silurian to Carboniferous are colored as showing between the granites of the range and the Green River beds of the Green River Basin, whereas the fact is that the Tertiary beds (Wahsatch formation) are directly superimposed on the granitic rocks, the line of junction being frequently concealed by accumulations of morainal material.

Professor Comstock also colored an area of volcanic rock as extending southward east of John Day's River between it and the Green River Basin. This area is occupied by what we have named the Wyoming Range,* which is composed almost entirely of Carboniferous rocks. A large portion of the area represented by him as occupied by the Green River Group has the underlying Wahsatch Group as the surface formation. The map of the Green River Basin published by the Survey of the Fortieth Parallel in the western northern portion slightly overlaps our southern line in the eastern part of our district. Portions of this region were not visited by the Fortieth Parallel Survey, and therefore it was not thoroughly explored by them.† The map colored by them, as regards these parts, although generally correct, differs in a few minor details from the map as colored by us especially in the eastern portion.

DRAINAGE, MOUNTAINS, ETC.

Drainage.—The drainage of the district belongs to three systems, viz: Green River, Snake River, and the Great Basin.

It is not proposed here to go into the details of the drainage, as it falls more properly within the province of the topographer. All the details necessary for the elucidation of the geological structure of the district will be presented in the subsequent chapters.

The district is naturally divisible for the purpose of description into

*In the map accompanying his report, the name Wyoming is given to the mountains that previously were known as the Gros Ventre Mountains. We have transferred the name to the range just south, which was unnamed.

†Report U. S. Geol. Expl. 40th Parallel, vol. ii, p. 251.

three areas, corresponding to the division of the drainage, viz: The Green River Drainage Area, the Snake River Drainage Area, and the Great Basin Drainage Area. The first includes 5,223 square miles, the second 2,879 square miles, and the third 4,898 square miles.

Green River is the artery of the first area. It probably derives the largest amount of water from the Wind River Mountains, although a large number of its tributaries rise in the mountains and hills on the west side of the basin. Its course is generally south, and its tributaries on the west have southerly, easterly, and southeasterly courses. On the east the tributary streams are confined mainly to the extreme northeastern part of our district, there being no streams joining the Green on the east between the mouth of the New Fork and that of the Big Sandy, a distance of about 80 miles as the river is followed.

The streams flowing from our district to Snake River are John Day's River, Salt River, Blackfoot River, and the Portneuf River. The first two of these streams are approximately parallel, flowing north and joining the Snake beyond the limits of our district. The Blackfoot and Portneuf Rivers are both very irregular in their courses. The general direction of the Blackfoot is northwest, but some of its branches flow south and southeast, and others southwest. The Portneuf at first flows to the southward, approaching the bend of Bear River in a broad, open valley which is continuous from the Portneuf to the Bear. It then turns abruptly to the east and cuts across the Portneuf Mountains to the valley of Marsh Creek, when it turns to the northward and flows in a course parallel to its former one, although reversed in direction.

Bear River, which drains the third area, has, however, the most eccentric course. Rising in the Uintah Mountains, it flows generally northward, entering our district a little west of meridian 111°. It then continues northward along the east side of the Bear River Plateau until it is joined by Thomas Fork coming from the north. It then turns, and with a zigzag course flows across the end of the plateau, and loses its character as a river in the swamp or marsh that extends northward from Bear Lake. Emerging from the swamp, it continues northward and northwestward to the Great Bend at Soda Springs, where it reaches its most northern point, which is 61 miles from our southern line. Flowing westward through the gap at the north end of the Bear River Mountains, Bear River enters the broad valley that extends northwestward to the Portneuf. This valley is floored with basalt, and the river flows across it in a cañon that is cut some 200 or 300 feet below the surface of the basalt. From the west side of the valley it takes a southerly course through Gentile Valley, whence it flows by way of a cañon into Cache Valley. In the lowest portion of the latter it is joined by Logan Fork, and turns westward through the "Gates," from which it emerges into the Salt Lake Basin, and leaves our district, on its way southward to Salt Lake, in longitude 112° 8′, only 54 miles west of the point at which it entered. It has a course of some 200 miles within the limits of our district.

Plateaus.—The district is about equally divided between mountains, plateaus, and valleys. The greatest elevation is 11,490 feet in Wyoming Peak in the Wyoming Range. The lowest elevation is where the Bear finally leaves the district, being about 4,300 feet. The Green River Basin is mainly a plateau through which the streams flow in cañons from 100 to 400 feet in depth. The plateau slopes from the northward, where its elevation is about 7,500 feet, toward the south, where it is about 6,900 feet. There is also a slope on the west side toward Green River from the Meridian Ridge, Thompson Plateau, and the Wyoming Range.

Besides the Green River and Thompson Plateaus, there are the Ham's Fork Plateau and the Bear Lake Plateau, all of which will be hereafter described in detail.

Mountains.—The mountains of the district have in general the character of short, isolated ranges. The Bear River Range, extending south from the Great Bend of Bear River, is the longest within our district (having a length of 60 miles), and stretches some distance south of our line to join the Wahsatch Range. The Wind River Range occupies a small portion of our area in the northeast corner.

On the west side of Green River Basin are the Wyoming Mountains, and west of them the Salt River Range. Although short, these are important ranges. The Wyoming Range ends at the head of La Barge Creek, but the line of uplift is continued southward in the Absaroka Ridges. The Salt River and Wyoming Ranges both have north and south trends. West of the Salt River Range we have no mountains until we reach the Portneuf Range. The northern end of the Preuss Range, it is true, extends northward between the east and south forks of the Blackfoot, but the mountainous character is here nearly lost. Besides this, there are only comparatively low ridges and isolated groups of hills in the northern part of the district between the Salt River Range and the Portneuf Range. West of the Portneuf is a range to which we gave the name "Bannack." It extends southward, of very unequal height, to the head of the Malade Valley. Opposite the southern end of this range, at the head of Marsh Creek Valley, the Malade Range begins. This range consists really of two groups, the ends of which overlap each other. The southern one ends just north of the "Gates" of Bear River, and on the south side, some distance from the river, is the northern end of the Wahsatch Range. A few degrees south of east from the Portneuf Range is a group of hills, some of which attain the dignity of mountains. They are north of Cache Valley, lying between Marsh Creek Valley and Bear River. They will be described as the southern extension of the Portneuf Range.

On both the eastern and western edges of the Bear Lake Plateau erosion has removed the plateau character, and there are hills and ridges with north and south trends. This is more noticeable toward the northern end of the plateau. The hills on the east have been named the Boundary Hills, as the boundary line separating Wyoming and Idaho crosses them, following approximately their trend.

Following the strike of the beds on the west side of the plateau, northward across Bear River, we find the ridges soon rising into a range, the culminating peaks of which are found in Mount Preuss and the neighboring mountains. Farther north the strike of the beds seems to turn somewhat to the westward, and a number of ridges branch from the range and are seen as spurs separating the branches of the Blackfoot River.

North of Bear River Valley is Sublette Range, between Smith's Fork and Thomas Fork. The strata composing these hills or mountains pass under Bear River Valley as we follow the strike southward.

The western edge of the Ham's Fork Plateau is bordered by a line of hills with a north and south trend. They stand on the east side of Rock Creek and die out to the northward, where a second range, that marks the west side of Rock Creek, becomes the most prominent. The latter range begins in a plateau-remnant in the angle of Twin and Rock Creeks, and extends northward on the west side of Rock Creek and the east side of Smith's Fork, until it loses the character of a distinct range in the group of high mountains that connect the Salt River Range, the

Wyoming Range, and the Absaroka Ridge. This range really joins the latter, for the drainage of Smith's Fork and Labarge Creek separates them both from the two ranges that lie to the northward.

The mountains about the sources of the Labarge and Smith's Fork are very irregular topographically. The drainage flows sometimes with the strike of the rocks and sometimes cuts across at right angles, so that there appears to be no system either in the drainage or the mountains, except that the strike of the rocks is approximately north and south, and where erosion has not worn down the beds the ranges have trends corresponding to this strike.

With the exception of the Wind River Range, the mountains of the district belong to the Wahsatch system.

Valleys.—Owing to the isolated character of the mountain ranges, we have numerous valleys lying between them. In addition to the river valleys, or those due to the erosive action of the rivers, there are wider areas which correspond to the parks of Colorado. The impression made upon the mind as these broad valleys are seen from the mountains is that they must once have been occupied by lakes above which many of the smaller groups of mountains must have risen as island masses at least when the lakes were at their highest level. These valleys form some of the richest agricultural areas in the district. The principal ones are Ham's Fork Basin, Salt River Valley, Bear River Valley, Bear Lake Valley, Soda Spring Valley, Hollow Hand, Basalt Valley, Upper Portneuf Valley, Lower Portneuf Valley, Marsh Creek Valley, Malade Valley, Cache Valley, and Gentile Valley. Of these Cache Valley is the most celebrated, having been settled many years ago by the Mormons. It is now well cultivated and has many flourishing towns. Bear Lake Valley is also comparatively well settled, although it does not appear to be as favorably adapted for agricultural purposes as Cache Valley. Basalt Valley and the "Hollow Hand" are floored with basalt which came from craters that still exist in the region. All of these valleys will be treated of in detail in subsequent portions of this report and in the report of Mr. Gannett.

GEOLOGICAL FORMATIONS.

With the exception of the limited granitic areas along the western slopes of the Wind River Mountains in the northeastern corner of the district, and the prominent basaltic flows filling the valleys in the Blackfoot and Upper Portneuf regions, the rocks of the district are sedimentary. The following list gives all that are found in our district:

Archæan		Metamorphic.
Silurian		Sedimentary.
Carboniferous		
Jura-Trias	Triassic ?	
	Jurassic	
Cretaceous		
Post-Cretaceous ?	Laramie Group	
Tertiary		
Quaternary		
Basalt		Volcanic.

These will be considered in detail in the succeeding chapters, when the subdivision and thicknesses will be enumerated.

CHAPTER II.

ITINERARY.

GREEN RIVER CITY TO GRANGER.

The party took the field at Green River City, Wyo., June 1. The first month of the field season was occupied mainly with the survey of the drainage of Green River. The second day out from Green River City brought us into our district, and that evening the party camped at the mouth of the Big Sandy. Fording this shallow muddy stream on the third, the line of march was along its banks to the mouth of the Little Sandy. The next two days the Big Sandy was followed until we encamped on the 6th near where it emerges from the foothills of the Wind River Mountains. The Green River Basin, between the Big Sandy and Green River, has on some old maps been called the Great American or Colorado Desert. It is a broad almost unbroken expanse covered with sage (*Artemisia*) and grass. The prevailing formation is the Green River Group of the Tertiary, consisting of clays, sands, and marls, which on Green River form bluffs a couple of hundred feet high and outcrop in lower bluffs on the Big Sandy.

Our course so far was in general northerly. Reaching the foothills we skirted them travelling toward the northwest and crossing the various branches of Green River that form the new fork. We reached Green River near our northern line at the mouth of Lead Creek on June 9. Two days later we forded the Green, which was rapidly rising. In a few more days we would have experienced some difficulty in crossing.

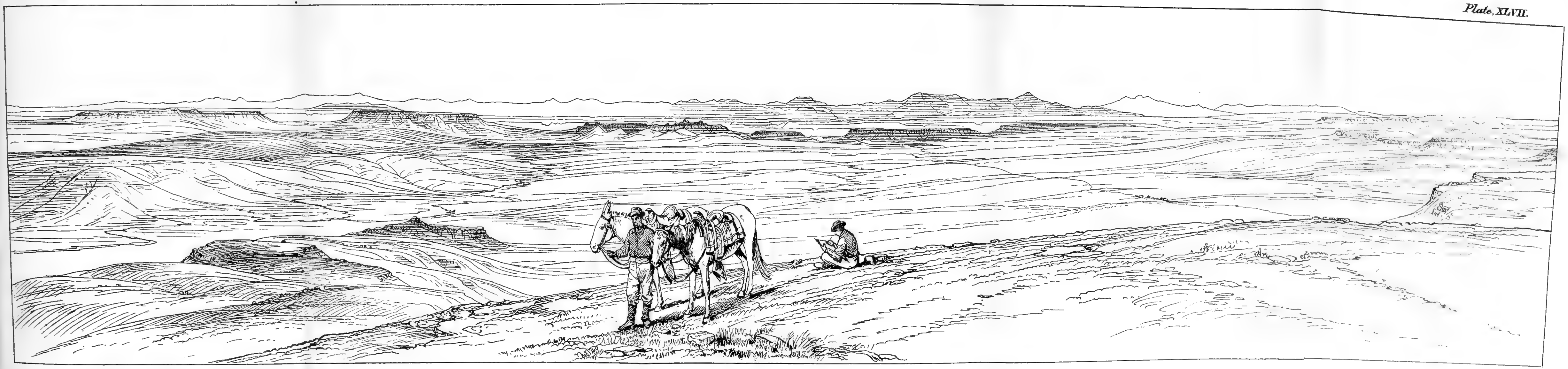
The valleys on Green River, and its branches in the northeast corner of our district, are all broad and well grassed. There are large areas here suitable for agricultural purposes and larger areas valuable for grazing lands. The prevailing formation is the Wahsatch Group, which is exposed by the erosion of the overlying Green River Group. The Wahsatch bad-land beds rest on the granitic rocks of the Wind River Mountain foothills. The junction is generally obscured by morainal material from the mountains. In a few places, however, the Wahsatch strata are seen. They always incline gently from the mountains toward the Green River Basin, thus indicating a slight elevation of the mountains since the deposition of the beds.

On the west side of Green River Basin the same beds are seen rising gently as we approach the hills that form the boundary of the basin on the west. The Wyoming Mountains form the boundary toward the north, but as we go south they die out and we have a series of parallel ridges that stand farther to the east. The rocks in the mountains are mainly Carboniferous limestones, but in the parallel ridges to the south we find Triassic, Jurassic, and Cretaceous rocks, the folding of which has caused the ridges.

From the mouth of Lead Creek we travelled southward on the west side of the Green, crossing Horse, Marsh, White Clay, Bitteroot, Piney, Feather, and Labarge Creeks. Below the mouth of Marsh Creek the old Lander road from South Pass to Old Fort Hall crosses the Green.

Plate, XLVII.

...suce, Green River Group.



Uinta Mountains in the distance. *Distant buttes and higher hills, "bad lands" of the Bridger Group.* *General [illegible]ce, Green River Group.*

VIEW IN THE GREEN RIVER BASIN.

LOOKING WEST FROM GREEN RIVER TOWARDS GRANGER.

We reached the mouth of Fontenelle Creek June 15. Here we found several ranches that seem to be in a flourishing condition. One of them furnishes butter for a number of the towns on the Union Pacific Railroad. The valley of Green River throughout most of this portion of its course is rather narrow and bordered with cañon walls. There are, however, several expansions of the valley, especially at the mouth of La Barge Creek, and where White Clay, Bitter Root, and Piney Creeks join the Green. The latter of these creeks appears to have considerable alluvial land of good quality along its course. There is scarcely any limit to the grazing land in this vicinity, as the mesas are covered with bunch grass. A very fair wagon-road, a portion of which is the old emigrant road, follows down the west side of Green River.

Sublette's road crosses Green River near the mouth of La Barge Creek, and crosses the Fontenelle about four miles above its mouth. It then bears away from Green River, going to the southwest, to the head of Crow Creek, one of the branches of Ham's Fork.

We followed the Fontenelle to the east side of the Meridian Ridge, which we crossed south of the Fontenelle Cañon, and then camped on the branch that comes through Absaroka Ridge. Between Meridian Ridge and Absaroka Ridge there are lines of hogbacks that extend north as far as La Barge Creek. These were named the Fontenelle Hogbacks. They also extend southward, but are not quite so marked, as the strata have not been so much eroded, owing to the fact that the fold becomes gentler in that direction, and the beds did not reach so great an elevation as they did farther north.

From our camp on Fontenelle Creek we turned southward, west of Meridian Ridge, to Crow Creek, and then crossed to the head of Slate Creek. The latter stream was then followed to the Green. South of Slate Creek beds of Bridger age are seen, forming buttes that are the outliers of the Bridger areas that prevail so extensively farther south. From the mouth of Slate Creek we followed Green River to the ferry, where the road from South Pass crosses. From the ferry we turned southward, arriving at Granger Station, on the Union Pacific Railroad, on the 22d of June. The Bridger Group prevails between Green River and Granger, as is shown also on the map of the Green River Basin by the survey of the Fortieth Parallel. This area was outside of our district, and Granger was simply our first supply depot.

GRANGER TO FORT HALL.

Taking a month's supply of provisions we started on our second trip June 24. Leaving Granger we followed up Ham's Fork. The second day's march brought us once more within the limits of the district. The valley of Ham's Fork has abundant agricultural land of fine quality, and the neighboring hills are well grassed. The prevailing formation on both sides, from Granger to the first branch coming in from the north, is the Bridger Group. Above the creek just mentioned the river cuts a narrow cañon through beds of Green River Tertiary age.

The road that follows Ham's Fork is obliged to cross and recross the river several times, and as there are no bridges, the route is one that is used only after the spring floods. A trail, however, follows the north side, and this we utilized, following it through the cañon which the stream cuts in its way across Oyster Ridge. Just as the stream enters this cañon, it turns at right angles to its former course. We forded the stream on the wagon-road just above the bend, and followed up the right bank until we reached the Sublette road, which comes across from Crow

Creek. After crossing Ham's Fork this road ascends the plateau on the west side, and continues its course to the northwest, crossing Rock Creek and following down a branch of Sublette's Creek to the valley of Bear River. At Smith's Fork we left this valley and followed the latter stream to its head where the Lander road crosses it. Turning eastward we crossed via Thompson's Pass to the east side of the mountains. The road keeps south of the southern end of the Wyoming and Salt River Ranges, crossing the high ridges which extend southward. Leaving Smith's Fork the road follows for a short distance down Labarge Creek, but soon comes out on the head of Piney Creek at the north end of Thompson plateau. The eastern edge of this plateau marks the western limit of the Tertiary beds of the Green River Basin. North of the plateau an anticlinal fold (Meridian Fold) in Cretaceous and, perhaps, older beds marks the limit for some distance. The streams from the mountains cut across this anticlinal in cañons. The Thompson plateau is composed of Carboniferous rocks. As we proceed northward the Tertiary strata reach up nearly to the summit of the anticlinal, covering and concealing the eastern half. On the west, between the anticlinal and the mountains, the drainage shows a tendency to north and south courses outside of the main valleys, which are east and west. At the head of the cañon cut across the anticlinal the streams are therefore found to have united. This is very marked in the case of Piney Creek, but is also shown in the streams farther north. The strata between the anticlinal and the mountains dip to the westward with, of course, north and south strikes, which, from erosion, gives a series of low hogback ridges. The same right-angled arrangement is seen in the mountains, but to a lesser degree, and it is due to the fact that the Carboniferous limestones also dip to the west. We followed a trail, that was often very dim, from Piney Creek to Lake Creek, and thence across Bitterroot and Lander Creeks to Marsh Creek, keeping between the mountains and the anticlinal ridge already referred to.

Reaching Marsh Creek, we found a large and well-marked Indian trail leading up the creek. We followed this trail to the head of the creek and across McDougal's Gap. The ascent to the pass is easy and gradual. The descent from the summit to the level of McDougal's Creek is abrupt, and for some distance down the creek the trail is very steep and rocky, with some very heavy grades. The cañon of McDougal Creek is narrow throughout its entire length, having no alluvial bottoms until the valley of John Day's River is reached. The latter stream separates the Wyoming Range from the Salt River Range. Both ranges are full of first-class mountain peaks. From the mouth of McDougal's Creek we went up John Day's River until we were opposite Wyoming Peak. After making a station on this peak we retraced our steps to the mouth of Sickle Creek, which comes into the river nearly opposite McDougal's Creek. The valley of John Day's River is cañon-like throughout almost its entire length, and it is well timbered with pine and spruce. The largest area of bottom land is just above the mouth of McDougal's Creek, where an island widens the river.

We followed Sickle Creek to its head at McDougal's Pass. On the west side of the pass we found a huge snow-bank filling the gorge at the head of Glacier Creek. Several of the side gulches farther down were also found to be filled with snow-banks. The trail down the creek is rough. Not only is it very rocky, but it is also much obstructed by timber. The Salt River range is composed largely of Carboniferous rocks. The change as we emerge from the gloomy cañon of Glacier Creek and come out into the broad valley of Salt River is striking.

The valley of Salt River is admirably adapted for grazing purposes, being covered with an abundant growth of bunch-grass. The surface of the valley is covered with drift derived from the mountains, and this drift appears to be made up largely of coarse pebbles, which would perhaps interfere somewhat with the use of the land for agricultural purposes. On the river bottom, however, the land is of an excellent quality. We traveled southward in the valley, making stations on the peaks of the range. We forded Salt River above the mouth of Crow Creek, and crossing once more the Lander road, followed an Indian trail up the creek. The hills west of Salt River are high and broken, with a tendency to form parallel ridges, between which there are broad valleys. After working the country between Crow Creek and Beaver Creek, we turned northward through one of the broad valleys just referred to, following down the south fork of Smoking Creek, which joins the main stream near the old Salt-Works, which are now deserted. Here again we came upon the Lander road. We now followed it over into the valley of John Gray's Lake. After making stations in the isolated hills south of this marshy lake, we once more abandoned the road and followed down the Blackfoot. The course of the Blackfoot is very winding through a basalt-covered plain. Bordering it are numerous craters and volcanic buttes, and frequently the stream cuts cañons in the basaltic layer, and from these often emerges into broad meadows and marshy areas. The river describes a semicircle, and Lander's road, which we left at the head of the stream, follows what might be called the diameter of this semicircle, so that by following the river we once more reached the road, this time at the ford of the Blackfoot. Near here we noticed large droves of cattle, which were being driven eastward. The valley of the Blackfoot formed an excellent resting-place, well suited, as it is, for grazing purposes. From the ford we traveled eastward on the road to the head of Ross's Fork.

After making a station on Mount Putnam, we crossed back again to the head of the Portneuf and skirted the east side of the hills south of Putnam until we reached the point where the river leaves the Upper Portneuf Valley. From this point the Portneuf was followed to the Snake River Plain. Basalt was found extending through the upper cañon and in the lower valley almost to the plain. Above the lower cañon the basalt forms a table between the Portneuf and Marsh Creek.

FORT HALL TO FRANKLIN.

We reached Fort Hall on the 6th of August, thus completing our second trip. A few days were spent in refitting the outfit. Every facility was afforded us by Captain Bainbridge and Lieutenant Hall. Having taken up our supplies that were awaiting us, we started on our third trip, which was to end at Franklin, in Idaho, where our next supply depot was located.

From Fort Hall we proceeded southward up Lincoln Valley and across to the Upper Portneuf Valley, crossing the route taken before going to Fort Hall. The mass of hills south of the Portneuf Cañon were next examined, and we then turned eastward to Soda Springs. At the latter place several days were spent in the examination of the interesting group of springs located there, and in the determination of the geology and topography of the surrounding country.

The bend of Bear River at Soda Springs is one of the most remarkable features in the whole district. The divide between Bear River and the Upper Portneuf is a basalt plain, which seems to have had its source

partly in craters in the Blackfoot Valley, and partly in some craters just north of the bend, where the Bear passes out into the valley. The north end of the Bear River Mountains terminates in Sheep Rock. North of the bend the mountains consist of isolated hills and ridges of Carboniferous and Jurassic rocks with basalt-covered valleys between them. Carboniferous and Jurassic rocks also occur east and northeast of the bend, and in this region there are several interesting folds. From Soda Springs we followed up Bear River, passing through Georgetown, Bennington, and Montpelier.

Above Bennington the valley of Bear River is wide, and, as the lake is approached, becomes flat and marshy. This portion of the valley is well settled, and the farmers appear to be doing well. The great objection appears to be the elevation of the valley, which is probably the cause of the frosts late in the spring and early in the fall. This portion of the valley is, however, better off in this respect than the Upper Bear River Valley. In the latter, near the mouth of Smith's Fork, about July 1, when we were there, there were heavy frosts nearly every night. In order to keep cattle successfully through the winter, one of the farmers living in the settlement at the mouth of Smith's Fork told me it requires them to put up one and a half tons per head. He also informed me that the weather we were then experiencing was exceptional. All these valleys, however, are excellent summer ranges. Near Montpelier, and on the west side of Bear Lake, the crops of wheat were large and the settlements all seemed to be in a prosperous condition. At one place I was shown some apples that grew there in 1877, but fruit crops in this region are generally understood to be precarious.

At the south end of Bear Marsh, Bear River emerges from the marsh into which it entered after coming from a cañon a few miles north of Bear Lake. This cañon begins a short distance below Thomas Fork. Sublette's road, which we had been following from Soda Springs, crosses the hills north of the cañon, sometimes coming down to the river's edge. At several points there are broad alluvial bottoms, especially as the mouth of Thomas Fork is approached. Between Thomas Fork and Smith's Fork the valley narrows, but south of the latter again expands. Beyond the alluvial bottom, which immediately borders the river, there is a wide drift-covered valley, bordered on the east by hills which soon develop into mountains toward the north. Formations from the Carboniferous to the Wasatch Tertiary are represented, the latter resting on the upturned edges of the older rocks near the south line of the district. On the west side, also, the same unconformability is noticed, the variegated sandstones and conglomerates extending farther to the north than on the east, and forming the Bear Lake Plateau, which is really the northern extension of the eastern side of the Bear River Plateau mapped by the survey of the fortieth parallel. On the west side of the plateau, erosion has left a range of hills that are about 1,500 feet above the level of the lake. There is a steep descent to the edge of the lake which leaves but a narrow beach margin. We crossed the Bear Lake Plateau a few miles north of our south line, reaching the south end of Bear Lake at Lake Town. The western shore of the lake was then followed and the eastern edge of the Bear River Mountains worked up. West of Paris, a town a few miles northwest of the lake, we crossed the Bear River Range to the head of Mink Creek, a branch of Bear River.

The Bear River Mountains are composed of Silurian and Carboniferous rocks, mainly quartzites and limestones. Between Bear Lake and Cache Valley there is a rather broad synclinal fold complicated by secondary folds, and this has resulted in breaking the Bear River Moun-

tains into two subranges, which are especially well marked toward the southern part of the district.

Facing Bear Lake Valley the mountains are not very rugged, and although the peaks are high, the ascent to them is comparatively gradual. The western side of the fold is the highest, forming the peaks that overlook Cache Valley. The basset edges of the strata face the west and give the range an extremely rugged face. The mountains are steep and rise abruptly from the valley. The cañons from which the numerous streams emerge into the valley are very picturesque, and, what is of far more importance to the settlers, furnish ample supplies of timber, building-stone, and lime. Numerous saw-mills and lime-kilns have been erected in nearly all the cañons.

While at the head of Mink Creek a day's trip was made into Gentile Valley, a valley well adapted for agricultural purposes, extending from the cañon of Bear River northward to the southern limits of the basaltic flow that fills Basalt Valley and through which Bear River cuts a cañon several hundred feet deep.

There are a number of ranches in Gentile Valley, and all seem to be in a flourishing condition.

FRANKLIN TO OGDEN.

On the 6th of September we reached Franklin, our third and last supply depot for the season. Delaying only long enough to get our supplies, we continued southward along the east side of Cache Valley to the mouth of Logan Cañon. After making a station at the forks of Logan River in the cañon, we crossed to the west side of the valley and turned northward along the east side of the Malade Range to Red Rck Pass, through which we crossed to Marsh Creek Valley. From the latter we again turned southward into Malade Valley, with which our season's work ended.

There is no doubt, as Dr. Hayden pointed out in his reports for 1870 and 1871,* that all these valleys were once filled by lakes. These lakes were connected. Cache Valley, Malade Valley, Marsh Valley, and Basalt Valley were all occupied by lakes which appear to have "commenced in the Pliocene epoch and continued on up to the present time." A view of these valleys obtained from one of the numerous peaks overlooking them renders their relation to each other very apparent. The isolated hills forming the Malade Range are seen to have formed islands that rose above the waters of the old lake. The modern Tertiary deposits are seen jutting against the older formations that enter into the structure of the mountains, and these Tertiary rocks seem to pass by gradation into the more modern deposits found in the central portions of the valleys. The clays and sands of these recent deposits are well exposed along Bear River in the northern part of Cache Valley. The further consideration of these lake basins will have to be left for a subsequent chapter.

From the Malade Valley our course was southward along the western base of the Wahsatch Range to Ogden, at which point the party was disbanded for the season.

The party was in the field one hundred and twenty-two days, during which time seventy-two camps were made, and over thirteen hundred miles traveled by the pack-train. The amount of traveling done by the scientific corps is very much larger, being generally from two to

*Report U. S. Geol. Survey for 1871, 1872, p. 20.

three times as much. The total number of stations made was 346, and the area surveyed, as already stated, was 13,000 square miles.

In this chapter I have endeavored to give a general idea of the district, and in the succeeding ones will present the details obtained, and conclude with the special consideration of the geological formations noted as occurring in the district.

From the fact that the area examined was so large the results are somewhat incomplete in detail, the general features claiming attention first. The plan of working with the topographer from the high stations from which extensive views of the country are obtained, and of generalizing from these stations the more detailed data obtained along the line of march, and using the topographical locations, insures greater accuracy and rapidity in the work than could be obtained were the geologist to devote his time to detailed work in the ravines and gulches, especially in a country of which there are no existing maps that are sufficiently correct to delineate the geology. The nature of the country also facilitates this mode of working, as it is generally bare of dense timber, the vegetation being scanty and erosion having so exposed the rocks that the conditions of the strata are easily seen, and the geological structure of the country for many miles around the station readily recognized.

The geological map is therefore colored with a considerable degree of accuracy, although much may be left for future investigation in the way of detail, as the geologist is necessarily unable to visit every point in his district, notwithstanding the fact that he has overlooked his entire area from the stations.

CHAPTER III.

DESCRIPTIVE GEOLOGY—GREEN RIVER DRAINAGE AREA.

GREEN RIVER BASIN—WIND RIVER MOUNTAINS—OYSTER RIDGE—HAM'S FORK BASIN—HAM'S FORK PLATEAU—ABSAROKA RIDGE—MERIDIAN RIDGE—FONTENELLE HOGBACKS—MERIDIONAL VALLEY—WYOMING RANGE.

The present chapter will be devoted to the description of the Green River Basin, or rather to that portion of it which falls within the limits of our district, *i. e.*, the northern and western portion, and the western boundaries. So uniform, however, are the conditions of the geological strata and the structure of the basin, that the description of one part naturally gives a good idea of the whole.

GREEN RIVER BASIN.

The Green River Basin is an elevated plain, or plateau, extending northward from the Uintah Mountains to the Wind River and Gros Ventre Ranges, and reaching eastward from the others of the Wahsatch system until it becomes merged in the Laramie plains, which extend westward from the uplifts of the Rocky Mountain system. Thus we see that the northern, southern, and western boundaries are well defined, while on the east an arbitrary line must be assumed. That portion of the basin lying within our district extends southward to about the latitude of the mouth of the Big Sandy and north to that of the mouth of Lead Creek. The eastern line is approximately the Big Sandy River and on the west the Absaroka Ridges and the Wyoming Mountains. With the Ham's Fork Basin it includes an area of more than 5,200 square miles.

The elevation of the basin is from 6,000 feet to 7,000 feet. The general level between the Big Sandy and the Green is about 6,500 feet, and this is very uniform, although the surface is considerably eroded in places. The streams are generally in cañons or cañon-valleys a couple of hundred feet below the general level. On the west the country rises somewhat as the mountains are approached, and the same is true as we approach the Wind River Mountains. Geologically considered, the basin is Tertiary, the Green River Group prevailing. In the centre of the basin the strata appear to be horizontal, but as the edges are approached the beds are seen inclining towards the central part of the basin, showing that an elevation took place after the deposition of the Tertiary beds that now form an undisturbed succession in the centre of this ancient Lake Basin.

The accompanying illustration gives a good general idea of the appearance of the basin, showing especially the effects of erosion, which are more marked towards the south. Between the Big Sandy and Green River the surface is much more level, as we have already said. Early in the summer, when the surrounding mountains are still snow-covered, the scenery possesses great beauty. Dr. Hayden, speaking of the Wind River Mountains as seen from the Big Sandy, in 1870, says:* "As the

* Report U. S. Geol. Surv. Terr., 1870, 1871, p. 46.

morning sun shone on them and scattered the mist and smoke from their summits, they seemed not far distant, and loomed up along the horizon with a sharp, clear outline that rendered the view most grand and imposing. Fremont's and Snow Peaks were clearly defined, and the series of sharp peaks that project from the main ridge seemed to diminish in height far toward the sources of Green River. In no country in the world, it seems to me, can such a comprehensive view be presented to the eye at a glance as at this point, where it can take in one of the loftiest of the ranges which form the main chain of the Rocky Mountains, stretching along the horizon for at least one hundred and fifty miles." Frémont, in his report, speaks in glowing terms of the Wind River Mountains, and compares the scenery to the finest in Europe.

WIND RIVER MOUNTAINS.

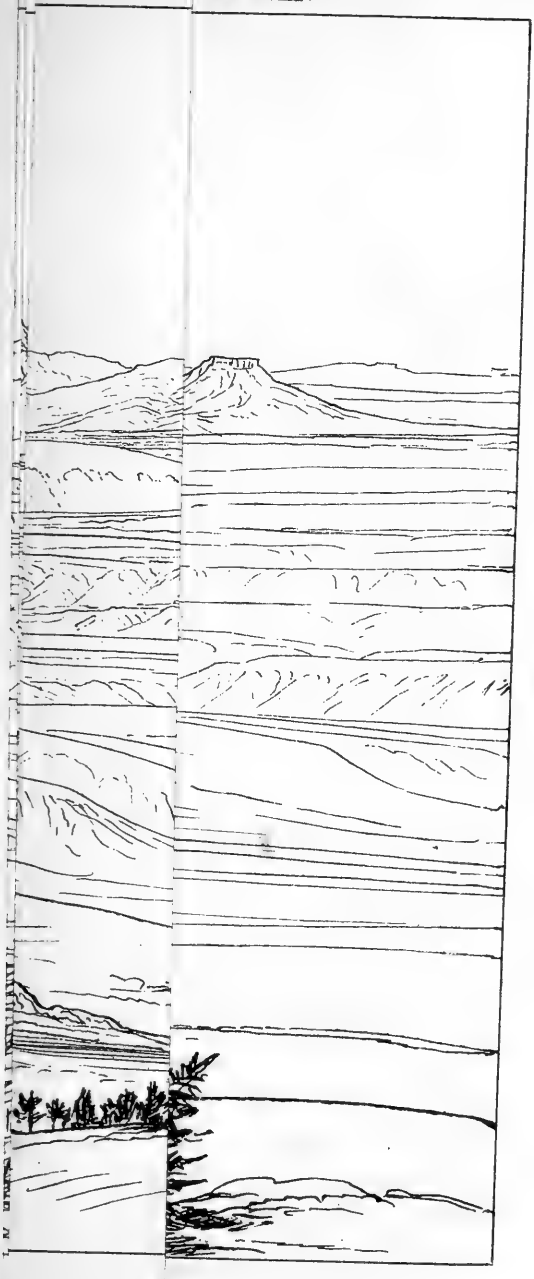
The Wind River Mountains properly fall within the district assigned the Sweetwater Division, and will be fully treated of in Dr. Endlich's report. Still, as our division skirted the western foothills of the mountains, there are several points that ought to be referred to here.

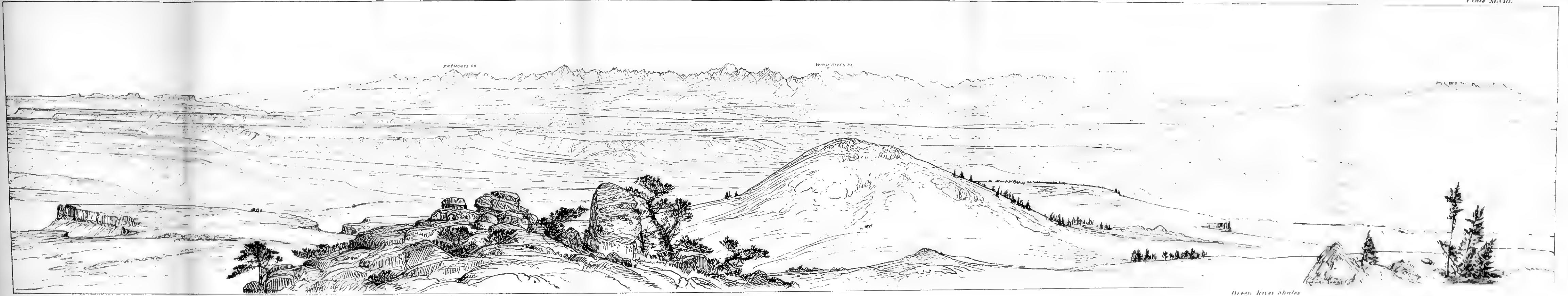
Professor Comstock, on his geological map, has colored a series of formations from the Potsdam sandstone to the Carboniferous, (Coal Measures) inclusive, as outcropping on the west side of the mountains between the head of the Big Sandy and Union Pass. As our party skirted the edge of the mountains as far north as the heads of the New Forks of the Green, we are prepared to say that in this distance the Wahsatch Group of the Tertiary is superimposed to the granite, the junction being frequently concealed by moraines. These latter will be described by Dr. Endlich, who traced them from the mountains to the basin. Outside of the foothills there are several granitic buttes, Fremont's being the largest, which seem to have risen above the lake as islands.

The fact that the older formations do not outcrop on the southwest or west side of the mountains was noted by Dr. Hayden in 1870. In the report for that year he says: "I could not ascertain that any of the older sedimentary rocks are exposed along the western side of this range, from the South Pass to the sources of Green River. Ridges of the Lower Miocene Tertiary strata along the western limit of the metamorphic rocks form an unmistakable shore-line of the ancient lake. Between this shore-line and the foothills of the mountains is a belt of metamorphic slates and gneiss, covered here and there with Pliocene marls." Our investigations confirm the absence of the older sedimentary rocks. The Pliocene marls referred to do not extend as far as our district. Dr. Endlich will treat of their occurrence near South Pass.

The shore-line of the ancient lake was undoubtedly granitic, as is shown by the character of the deposits. The older formations probably occur in the central portions of the basin, where they are concealed by the Tertiary strata. The Wind River Range belongs to the same system as the Front Range of Colorado, and probably like it stood above the level of the water in very early time. I have in other places indicated my belief that the Rocky Mountains of Colorado were affected by a subsidence extending through a long period of time, and I think it probable that the Wind River Range partook of the same movement, and that its present elevation is due to an elevation in Post-Cretaceous time. Dr. Hayden was inclined to consider the Sweetwater Valley an extension to the east or southeast of the axis of the Wind River Range. If so, it

XLVIII.





NORTH-WEST SIDE OF THE **WIND RIVER MOUNTAINS.** FROM GREEN RIVER BASIN.

marks the connection with the ranges of Colorado and Eastern Wyoming. The further discussion of this question will have to be reserved for a subsequent portion of the report.

DRAINAGE.

The main stream by which the Green River Basin is drained is the stream from which it takes it name. In considering the drainage, I shall take up the eastern branches of Green River first, and give the general geological notes obtained while following the streams, leaving the topographical details to be given in Mr. Gannett's report.

Big Sandy.—The Big Sandy River joins the Green near our southeastern corner and forms approximately the eastern line of our district. On the east side, in the angle between it and Green River, the beds are variegated sands and marls, generally of gray and dull reddish colors. These beds form bluffs on the Green a short distance below the mouth of the Big Sandy, and were referred doubtfully to the Bridger Group.

They appear to be mainly arenaceous and argillaceous, and may represent the base of the Bridger Group, although the point is hard to determine, as the line between the Green River Group and the Bridger Group is somewhat indefinite. Professor Cope considered them of Bridger age,* and they are also so colored on the map of the fortieth parallel survey.† These beds extend northward and eastward, and contain fragments of vertebrate remains. We travelled northward on the west side of the Big Sandy, and the area extending westward I have colored on the map as occupied by the Green River Group. The exposures on the east side of the Green at the mouth of Fontenelle Creek and northward indicate this to be the surface formation. Toward the south, and especially in the angle between the Green and Big Sandy, there may be remnants of the Bridger beds. This region affords but few outcrops, and is mainly a desert-like sage-covered plateau. Desolate and barren as it appears, if it could be irrigated it would doubtless produce all the crops permitted by the altitude, for its soil contains more numerous elements of fertility than many regions of the West that have been found to be highly productive. The country is not to be condemned because it has the appearance of a desert waste, and produces only cactus and sage brush products which afford but little indication of the character of the soil. A number of desert localities, Salt Lake Valley particularly, have afforded proof of the fertility of what was at first considered barren land. This area, extending westward to the Green from the Big Sandy, is a broad, almost unbroken expanse, on which there is a considerable growth of grass scattered among the sage. The area is covered also partly by drift, which conceals the the strata.

At the mouth of the Little Sandy the following section was obtained:

Section No. 1.

Top.	
1. Brownish gray, rather coarse sandstone, with pebbly layers, containing fragments of *shark's teeth* and *Goniobasis tenera*, Hall	50 feet.
2. Coarse, yellowish sandstone	
3. Indurated, argillaceous shales, with fragments of broken wood and shark's teeth	

*Report of U. S. Geol. Survey for 1873, 1874, p. 439.
†Atlas map II, Green River Basin.

These beds I have referred to the Green River Group. They are exposed on the right bank of the Big Sandy, just above the mouth of the Little Sandy. The course of the Big Sandy from this point to the Green is south and southwest. It is in a low cañon without bottom-land or groves, and is a shallow, rather sluggish stream, with a sandy bottom. The rocks between the Big and Little Sandy are probably the same as those given in the section above. Farther east, however, there are higher beds which form high table-like buttes, resembling Pilot Butte, that forms so prominent a landmark farther south.

As we approach the mountains the valley of the Big Sandy improves somewhat. It is wider and has better grass, but the surrounding country is still sage-covered and monotonous. Variegated beds are seen resting on the granite. The following is a section made between camps 4 and 5:

Section No. 2.

Base.	
1. Greenish gray and pinkish arenaceous bad-land beds	100 feet.
2. Yellowish marls? and sands	200—300 feet.
3. White sandstones, shales and marls? with variegated argillaceous and arenaceous beds at the top. These were noted from a distance	?
	300 +—400 + feet.

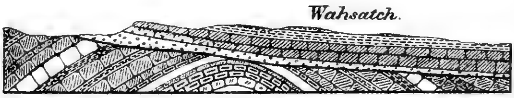
The strata incline about five degrees from the mountains and are probably of the Wahsatch Group, although the upper layers resemble the lower beds of the Green River Group. These Wahsatch sands rest directly on granitic rocks, as already stated. The sources of the Big Sandy are in the district surveyed by the Sweetwater division, and will be found described in Dr. Endlich's report.

New Fork of Green River.—On the southwestern slopes of the Wind River Mountains and in the adjacent foot-hills a number of beautiful clear streams have their sources. These streams are all swift and obstructed by bowlders. Along their courses are abundant evidences of glacial action, and long moraines extend from the mountains bordering them as far as the edge of the basin. Glacial lakes also are numerous. The creeks after emerging from the foot-hills form the New Fork of Green River before joining the main stream. Our work during the season did not extend into the foot-hills, so that the description of the moraines and other glacial phenomena will have to be reserved for another report. The region through which the branches of the New Fork flow may be described as a "bad-land" country. This is owing to the fact that the rocks are mainly of Wahsatch age, especially those close to the mountains. As we leave the hills, cappings of Green River shales appear. There is good grass throughout, and antelope were abundant when we went through the country in June. Some of the valleys are broad and well suited for agricultural purposes, were it not for the great elevation. Willows are found along the streams, but timber is scarce outside of the foot-hills. The stream bottoms are very marshy and the creeks obstructed by beaver-dams. The northern rim of the Green River Basin is beyond the limits of our district and will be the field for investigation in 1878, and to the report for that year, when published, the reader will have to refer for additional information in regard to the sources of the New Fork of Green River.

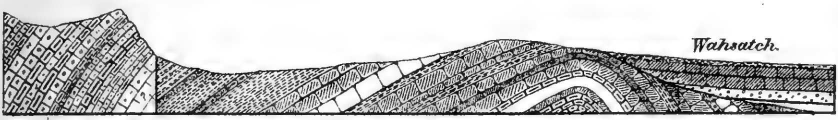
Green River.—Green River has a length of about 116 miles in our district. In the northern portion of the basin beyond our district the rocks are of Wahsatch age along the course of the river. Below the mouth of Lead Creek, Green River beds are seen capping mesa-like buttes. As

WYOMING RANGE

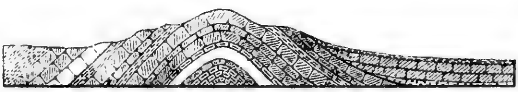
No. 1. Section between Horse and Marsh Creeks.



No. 2. Section North of Bitter-Root Creek.



No. 3. Section South of Bitter-Root Creek.



No. 4. Section South of Lake Creek.

No. 5. Section North of Piney Creek.

SECTIONS FROM WYOMING RANGE.

EASTWARD ACROSS MERIDIAN FOLD

TO GREEN RIVER BASIN.

far as Labarge Creek, however, the Wahsatch Group forms the largest part of the surface west of Green River. There is a dip to the eastward, so that on the east side of the Green the Green River beds form the top of the bluffs. The Wahsatch beds disappear a short distance below the mouth of Labarge Creek and from that point southward the cañon is in the Green River beds. This is due to the fact that the beds incline slightly to the southward and eastward, and the direction of the Green is also in general towards the southeast in this portion of its course. North of the Fontenelle the general course of the Green is south. There are two deviations from this; one is to the eastward in the valley where it is joined by Horse Creek, and the other is a bend to the westward, above the mouth of White Clay Creek. On the east, bluffs extend along the entire course of the river, but the western wall is broken down wherever a stream enters. The valley bordering the river is always narrow and generally cañon-like. Its agricultural capacity will be fully discussed by Mr. Gannett in his report.

The streams coming into the Green from the west, commencing at the north, are as follows: Lead Creek, Horse Creek, Marsh Creek, White Clay Creek, Bitterroot Creek, Piney Creek, Feather Creek, Labarge Creek, Fontenelle Creek, Slate Creek, and Ham's Fork. I shall take these up in the order given above, reserving the description of their sources until I consider separately the ranges in which they rise.

Lead Creek.—Only the mouth of this stream falls within the limits of our district. North of this creek the country appears to be well grassed, and when we were in there was full of antelope. Between Lead Creek and Green River is a butte about 400 feet high. Yellow sandstones outcrop low down in this butte and on the edge of Green River, but whether they are of the Green River Group or Wahsatch it is almost impossible to say. A little farther south the character of the Wahsatch beds appears to resemble that of the lower part of the Green River Group. On the map I have colored the Green River Group as capping the summit of the butte on which Station 12 is located. It, however, extends westward but a short distance, the Wahsatch beds soon forming the surface and rising on the hills that lie to the eastward of the Wyoming Range. The country between Lead Creek and Horse Creek is comparatively flat, with a slight slope from the hills toward the east.

Horse Creek.—This stream does not extend into the Wyoming Range, but has its origin among the high hills that lie to the eastward of its northern end. These hills are composed mainly of greenish and yellow sandstones that are of probable Laramie age, and on these beds rest unconformably the variegated conglomerates and sands of the Wahsatch. Between the hills and the mountains is a rough-like depression, from which on the west rises the bluff face of the Wyoming Range. Horse Creek is formed by two principal branches, to the southern of which we gave the name of Lynx Creek. Both streams have very straight eastern courses, and until they reach the Green River Basin proper are in cañon. These cañons are cut across a series of folds in the Laramie (?) sandstones and underlying beds. One of our stations, No. 50, was between the forks of Lynx Creek. It was on one of the several buttes that are capped with a conglomerate considered to be a part of the Wahsatch Group. This conglomerate is composed of rather fine quartz, the pebbles and larger masses of limestone, the latter containing traces of Carboniferous (?) fossils. The pebbles are angular, and were evidently derived from the range that rises to the westward. The inclination of the beds is to the eastward, and on some of the neighboring buttes the angle is as high as 20°. The sandstones on which these conglomerates rest, dip

slightly toward the west, the dip increasing somewhat near the range. Soon after crossing the western rim of the Green River Basin the two branches unite, and a few miles below are joined by a small branch coming from the north, when a more southerly direction is assumed, and the creek flows out into a broad valley, in which it is side by side with the Green, and finally, to use an anatomical term which exactly describes it, joins the latter by anastomosis. There are at least five islands formed by the two streams in the lower end of the broad valley. This valley forms one of the finest meadow areas on the Green, with a few groves of cottonwoods. The Green enters the valley flowing south, and near the southern end turns abruptly eastward, leaving it to flow southward into a cañon-like valley that extends to the mouth of Piney Creek. East of Green River are low bluffs of variegated Wahsatch beds, and farther back high terraces or remnants of terraces appear capped by the white beds of the Green River Group. Horse Creek hugs the bluffs on the west side of the valley, and between the creek and Marsh Creek an area of Green River beds extends westward toward the hills. Nearer Green River, however, the surface is much eroded, and all that remains of the Green River Group is to be seen as cappings of a few isolated buttes. The gray, greenish, and red marls and sands of the Wahsatch are the prevailing rocks. These are eroded into rounded hills covered with loose drift in places composed of pebbles of quartzite, reddish sandstones, and occasionally fragments of limestones, all evidently derived from the surrounding mountains, especially those to the west and north.

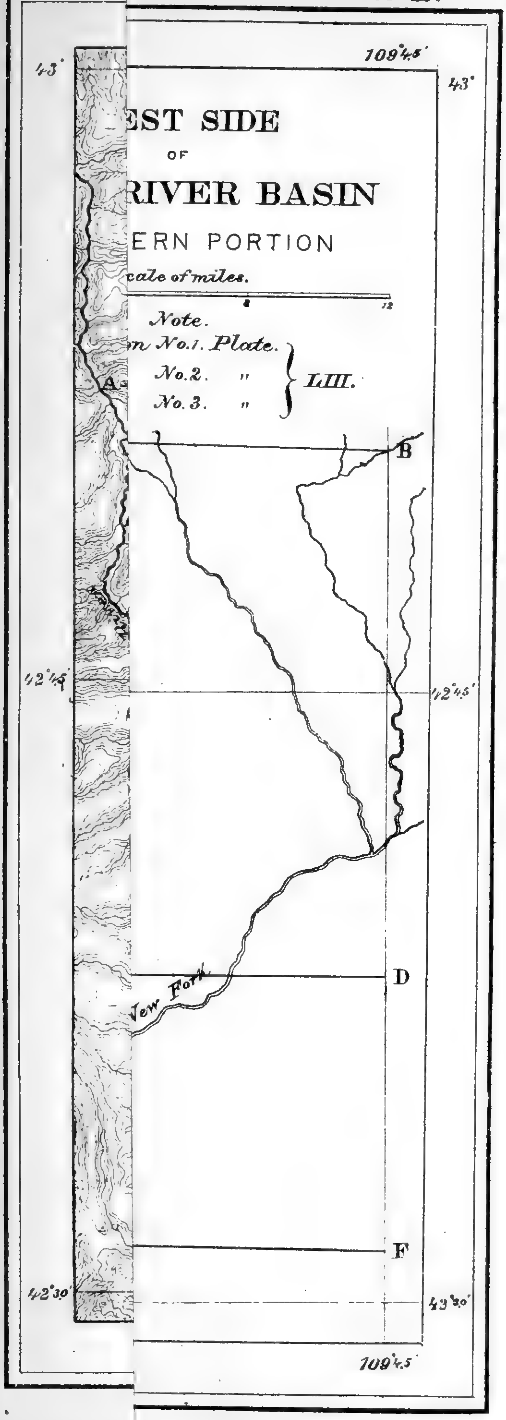
Station 13 is located about 3 miles south of Horse Creek and a little over 2 miles west of Green River. The summit is composed of a thin layer of hard white limestone, the upper surface of which is covered with petrified cases of caddis-flies which have been described by Prof. S. H. Scudder.* Below the limestone is a gray and yellow micaceous sandstone loosely aggregated. Still farther down are soft gray and pink beds that weather into bad-lands. The outcrop is about 100 to 150 feet. The country between Horse Creek and Marsh Creek is a "bad-land" country covered with sage-brush. Along the small creek that occupies the depression between Horse Creek and Marsh Creek there are numerous alkali flats.

Marsh Creek is one of the largest of the western branches of the Green, and is formed by two streams of about equal importance. The northern, to which the name Marsh Creek has been applied, collects its water from the Meridional Valley between the mountains and the line of uplift that forms the western rim of the basin. The Southern Branch rises among the Carboniferous limestones of the Wyoming Range and cuts across the Meridional Valley, receiving a branch from the south, and with an easterly course flows out into the basin through a cañon cut in an anticlinal of Jurassic? limestones. On these limestones the variegated Wahsatch beds are seen dipping unconformably to the eastward. This creek has been named Lander Creek. It joins the main stream about 12 miles from the rim formed by meridian fold, and from this point to the Green, Marsh Creek is in a broad valley lined with willows. All the streams in the basin are conspicuous for their want of timber. Between Marsh Creek and the Bitterroot, "bad-lands" prevail. On the eastern slope of the basin rim *White Clay Creek* rises and flows parallel to Marsh Creek, only a mile or two miles from it. Instead of cutting across to the Green as Marsh Creek does, it turns abruptly southward through a depression to join the river near the mouth of Bitterroot

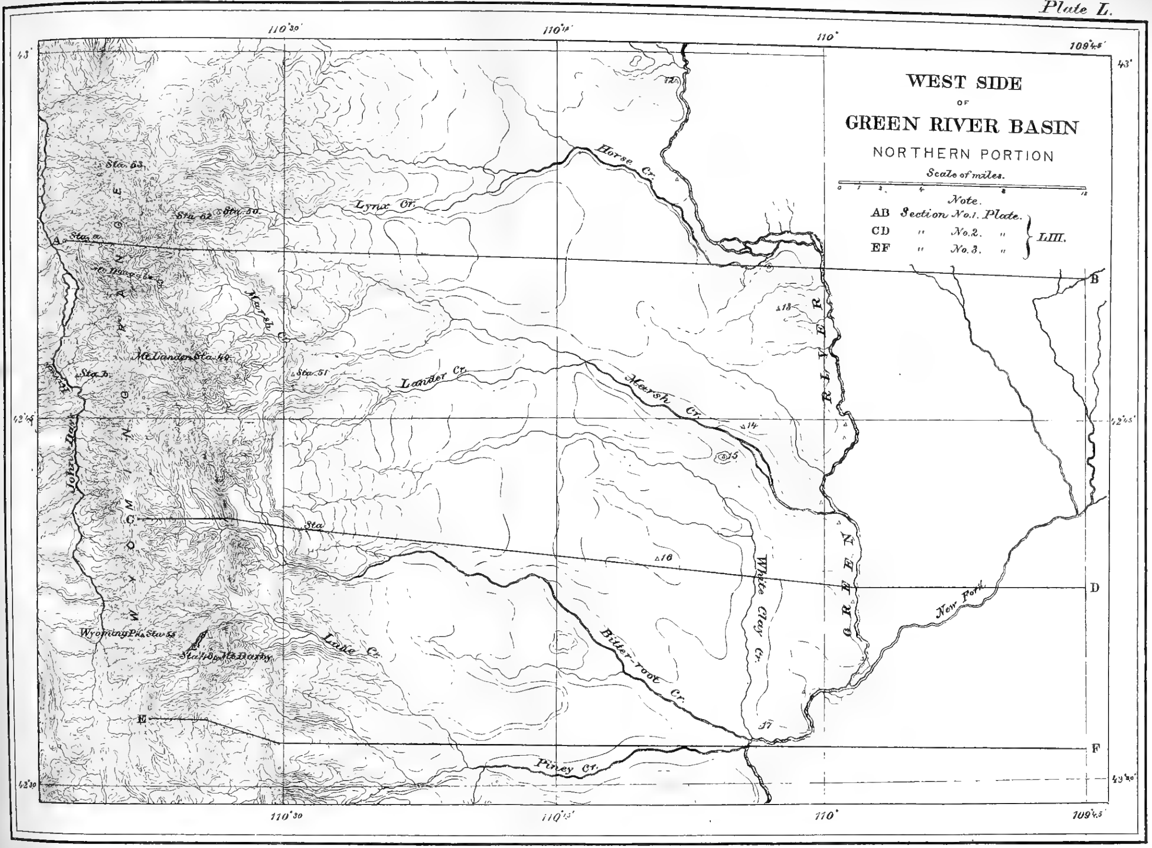
* Bulletin U. S. Geol. Surv., vol. iv, No. 2, p. 543.

U.S

Plate L.



43°
109°45'
43°
EST SIDE
OF
RIVER BASIN
ERN PORTION
cale of miles.
8
12
Note.
n No.1. Plate.
No.2. "
No.3. "
LIII.
A
B
42°45'
42°45'
D
New Fork
F
42°30'
42°30'
109°45



WEST SIDE
OF
GREEN RIVER BASIN
NORTHERN PORTION
Scale of miles.
Note.
AB Section No. 1. Plate.
CD " No. 2. "
EF " No. 3. "
LIII.
110°30'
110°15'
110°
109°45'
43°
42°45'
42°30'
Horse Cr.
Lynx Cr.
Marsh Cr.
Lander Cr.
Lake Cr.
Bitter-root Cr.
White Clay Cr.
Piney Cr.
New Fork
GREEN RIVER
WYOMING RANGE
John Day
Sta. 63
Sta. 62
Sta. 50
Sta. a
Sta. b
Sta. 51
Mt. Landen Sta. 49
Wyoming Pk. Sta. 58
Sta. 48 Mt. Darby
A
B
C
D
E
F

Creek. Station 14 is located on a butte north of the angle. The following is the section at that point:

Section No. 3.

Top.		
3.	Greenish-gray argillaceous sands with bands of yellow sandstones. Near the top is a band of limestones. At the bottom are drak-gray sandstones, weathering into rounded masses that lie scattered about, resembling grindstones	200 feet.
2.	Greenish-gray and pink marls?	(included above)
1.	Dull brick-red sands and clays with gray sandstones	40 feet.
		240 feet.

The thickness of these beds was measured with an aneroid barometer. The upper sandstones I have colored as belonging to the Green River Group, and the lower beds as the upper part of the Wahsatch. They weather into characteristic bad-land buttes. To the westward, I think, the Green River beds are in place, and, as seen from the basin rim, present a bluff edge facing the rim. Between White Clay Creek and the Bitterroot there appears to be a dip to the northeast or north, probably on account of the Carboniferous islands on Feather Creek. Between White Clay and the Green the country is mesa-like, capped with Green River sandstones. This is the result of a northern dip near the mouth of the Piney. In the cañon-like valley east of this mesa the Green is joined by the New Fork, which seems to change the course of the river to the west, so that it comes back to a point about due south of its course before it is shoved to the eastward by Horse Creek. This will be more readily understood by a reference to the map. On the east side of the Green below the mouth of the New Fork, and extending up the latter stream, are high bluffs capped with Green River shales with bad-land beds beneath. The capping beds form the surface extending eastward toward the Big Sandy. On the west the bluffs are also well marked, although not so high. Yellow and gray sandstones form the top, with the pink and red beds beneath. As the Green emerges from this cañon it is joined by White Clay Creek, and within a half a mile below by the Bitterroot and the Piney. They join the Green in a wide valley. The White Clay is a thick, white, muddy, alkaline stream in which the water is unfit for drinking.

Bitterroot Creek is a good-sized clear stream of pure water, rising in the Wyoming Range, and the Meridional Valley, so frequently referred to. Its general course is southeast through a country of rather uniform level. South of the stream are several isolated buttes of Green River beds.

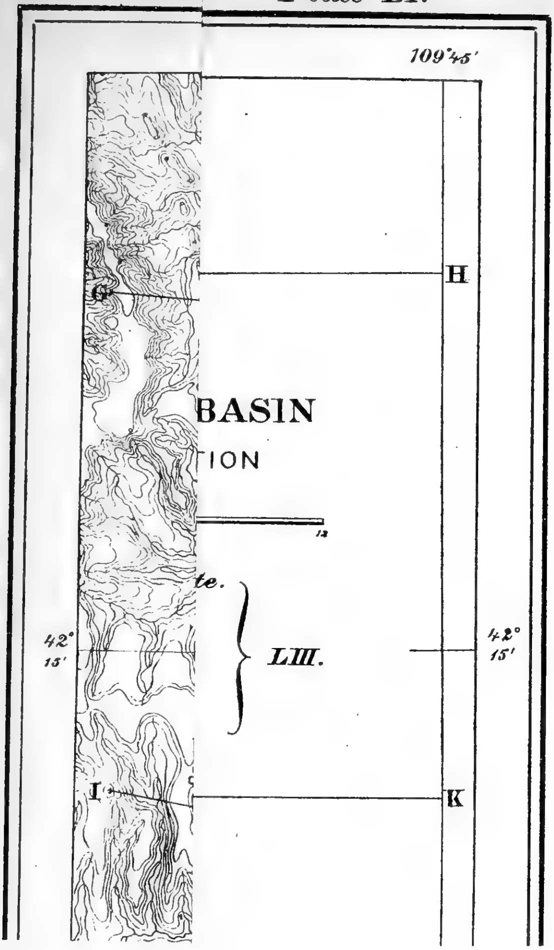
Piney Creek drains a larger area of country, north and south, than any of the creeks yet described. Its branches fan out in the country extending northward from Thompson Plateau to a point several miles north of Wyoming Peak. The branch rising in the country adjacent Wyoming Peak and Mount Darby has been named the Lake Branch, from a beautiful lake, about a mile and a half in length, that lies between Mount Darby and Wyoming Peak. The Southern Branch heads opposite the sources of John Day's River. There is a smaller Middle Branch rising in the eastern peaks of the range. All the branches have united in one good-sized stream at a point about 12 miles above the mouth. This point is at the northeast corner of a well-marked mesa of Green River shales and sandstones. This mesa extends about five miles to the eastward, and is a remnant showing that once the formation extended over all of this region. From Labarge Creek northward erosion

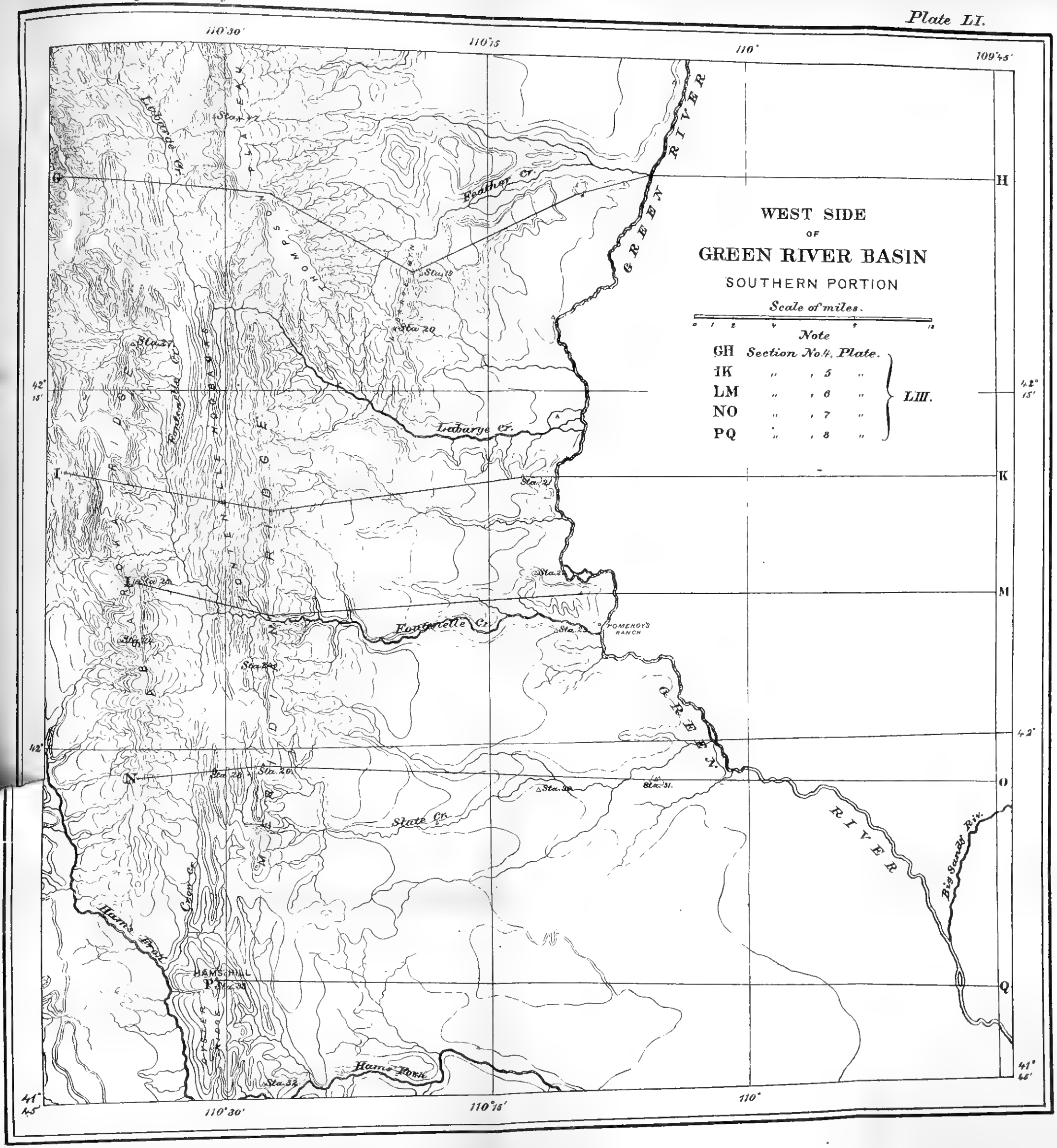
has been extensive, the Wyoming Range probably furnishing a great part of the water causing it. Farther south, where the mountains have diminished to hills, the covering of Green River beds still remains. Another reason is to be found in the fact that the greater elevation of the beds on the northern portion of the basin has exposed them more to the eroding influences.

From the junction of its forming branches Piney Creek flows almost due east to the Green. It splits into several streams near the river. The valley in which this creek and the Bitterroot flow side by side is one of the best along the Green. Its elevation is about 6,800 feet, being about 350 feet lower than the valley at the mouth of Horse Creek. Several ranches have been started on the Pineys, as the branching mouth of the Piney has been called. The old Lander cut-off road, which crosses Green River above the mouth of the New Fork, crosses the country between White Clay and Piney Creeks, and follows up the latter to Thompson's Pass, from which it crosses to the head of Labarge Creek, and thence to the head of one of the branches of Smith's Fork of Bear River.

Feather Creek.—Nine or ten miles below the mouth of the Piney, a small, dry creek bed is crossed. Followed up, this creek is seen to spread out feather-like on the slopes reaching eastward from Thompson Plateau. Hence its name. The upper branches contain water which extends some distance down the main creek. It has two main stems between which is a V-shaped mesa of Green River beds. West of this mesa is a hill of Carboniferous rocks surrounded by Wahsatch beds. This Carboniferous island was not visited, but is doubtless similar to the one just south of it known as Labarge Mountain. On the latter two stations were made, viz, Nos. 19 and 20. These stations are located on a long hill or mountain that forms a rather prominent landmark as we come down the valley of the Green. It is about 5 miles long, and composed of Carboniferous limestones, dipping about 25° to north 73° west. The trend of the mountain is about south 17° west. Station 19 was located at the north end, and Station 20 at the south end. The outcrop of limestones to the east of Station 19 is about 400 or 450 feet in thickness. The valley between the station, and the mesa is about 1,200 feet to 1,400 feet below the stations and 600 to 800 feet below the mesa top. The mesa just referred to is a mesa extending along the south side of Feather Creek toward Green River. This mesa is capped with the lower part (?) of the Green River Group, and slopes at an angle of 5° to 10° from Labarge Mountain toward Green River. The gap between the mountain and the mesa was not visited from want of time, but should be examined before the region can be fully described. It is probably filled with Wahsatch beds, judging from what could be seen from the summit of the mountain. If the latter is the remnant (western side) of an anticlinal, evidences of the eastern side might possibly be found appearing in places above the Wahsatch beds. As it shows now, it is a monoclinal ridge facing the east. A few indistinct crinoidal markings were observed on Station 19, and on Station 20 some indistinct *corals*, *Productus*, and a poor *Strophomena*. East of Station 20 near the foot of the mountain is an outcrop of sandstones and quartzites, but their relation to the limestones was not determined. West of the mountain is the main stream of Feather Creek, which flows around the north end of the mountain. From the creek, long slopes rise gradually to the Thompson Plateau. These slopes are smooth, with reddish exposures, which I have taken to be outcrops of Wahsatch and have so colored on the map. The beds appear to curve around the southern

U.S.G Plate LI.




WEST SIDE
OF
GREEN RIVER BASIN
SOUTHERN PORTION
Scale of miles.
Note
GH Section No.4, Plate.
IK " , 5 "
LM " , 6 "
NO " , 7 "
PQ " , 8 "
LIII.
110°30'
110°15'
110°
109°45'
42° 15'
42°
41° 45'
GREEN RIVER
RIVER
Big Sandy Riv.
Feather Cr.
Labarge Cr.
Fontenelle Cr.
State Cr.
Hams Fork
Crow Cr.
POMEROY'S RANCH
HAMS HILL
Sta. 19
Sta. 20
Sta. 21
Sta. 23
Sta. 26
Sta. 27
Sta. 28
Sta. 30
Sta. 31
Sta. 33
Sta. 52
G
H
I
K
L
M
N
O
P
Q

end of the mountain, but as the region on Labarge at the south end of Thompson Plateau was not visited, I cannot be certain of the exact relations. This is an interesting region and will repay the geologist who may be able to devote time to its detailed study and investigation. From Feather Creek south to Labarge Creek the surface rocks are the Wahsatch, with the exception of the mesa on the south side of the former creek. The Wahsatch variegated beds also form buttes and mesas, bright red colors predominating. As we approach Labarge Creek the level becomes lower and more uniform. Here there is a dip to the southward and also to the eastward, so that on the west side of the Green below Labarge Creek, the bluffs are composed entirely of Green River beds. On the east, however, a tongue of Wahsatch extends a short distance below the mouth of the creek. The sandstones, however, are the most prominent rock and are well exposed in the bluff on the west. In the lower portion of these sandstones above the mouth of the Labarge, on the east side of the Green, as well as on Fontenelle Creek, Professor Cope, in 1873, found "numerous remains of fishes similar to those of Green River City, with insects and their larvæ, shells like *Pupa* and *Cyrena*, and millions of Cypris."* The Green was at its highest stage when we followed it, and it was found to be impossible to cross to the east side. The country between the Labarge and Fontenelle is pleateau like, with a gentle inclination eastward as we approach Meridian Ridge. Green River shales and sandstones prevail, with, perhaps, Wahsatch near the ridge. The latter between the two streams was not visited, and therefore nothing definite can be predicated in regard to it, but it is probably composed of Jurassic and Carboniferous rocks. On the Green the sandstones of the Green River Group have a thickness of about 500 feet. East of the Fontenelle this thickness appears somewhat greater, shales forming the upper part of the beds. Ascending Fontenelle Creek the sandstones descend somewhat, and shaly beds show above. As we approach Meridian Ridge the beds rise gently and the variegated Wahsatch beds outcrop beneath, resting on the eastern slopes of the ridge. At the base of the latter beds, near the cañon, is a very coarse conglomerate, and above are bright red, loosely aggregated sands. The shales and sands of the Green River Group above the latter are much thinner than on the Green, as we would naturally expect. I searched for fossil remains in these layers, but without success.

Labarge Creek.—The upper portion of this stream is mainly in Cretaceous rocks that continue northward from the Fontenelle Hogbacks and will be described hereafter. It enters the basin through the cañon south of Thompson Plateau, and from this point its course is about east, while above the cañon it is south. The geology of this portion has already been given. It is a considerable stream, and enters the Green in several branches that spread over a wide meadow.

Fontenelle Creek was named after one of the early fur traders. It has its sources in the Absaroka Ridges opposite those of Ham's Fork. Thence the streams flow eastward and southward across and through the Fontenelle Hogbacks until all unite in one main stream at the Meridian Ridge, through which a cañon some 900 feet deep is cut to the basin. Thence the stream flows eastward through a plateau-like region to the Green. This plateau of Green River beds extends southward beyond Slate Creek and disappears beneath the Bridger Group north of Ham's Fork.

Slate Creek rises in the eastern and western slopes of the south end of

*Page 439, Report U. S. Geol. Survey for 1873, 1874.

Meridian Ridge. It is a small, alkaline stream. Cutting across the ridge in a comparatively deep cañon, it flows to the eastward near the top of the plateau extending southward from the Fontenelle. The surface here is rather barren, gravelly, and sage-covered, even along the course of the creek. To the southward buttes of Bridger beds, dark gray and blackish in color, are noted from Slate Creek. They also outcrop to a limited extent on the east and northeast side of the Green. The Green below the Fontenelle turns from its southerly course to flow toward the southeast. The following section was made in the bluffs between the two creeks:

Section No. 4.

Top.

5.	Yellowish and white laminated sandstones with a few bands of concretionary limestone with oolitic streaks. Very irregular layers of sandstones show in places; the thickness of these beds is about	100 feet.
4.	Thin, fissile, white shales with bands of sandstone	100 feet.
3.	Deep yellow sandstones somewhat massive	50 to 100 feet.
2.	Greenish and whitish shales, with bands of sandstone	50 feet.
1.	Rather massive yellow sandstones	200 feet.
		500 to 550 feet.

The thicknesses in this section were estimated. The lower layer (No. 1) often thins out, and the sandstones become laminated. They appear to lie just above the variegated beds. From the mouth of Slate Creek down, the river bottom on the Green is broad, and covered with good grass, and cottonwood groves. On the terraces back from the river sage-brush is abundant.

Ham's Fork.—Only the upper portion of this stream falls within the limits of our district, but the stream was followed from its mouth. About 25 miles from its mouth it is within our district, flowing approximately eastward along our south line. The bluffs on either side of the stream from Granger northward are composed of the sombre colored clays and sands of the Bridger Group, weathering into the bad-lands so characteristic of that group. A short distance below the limit of our district the following section was made in a bluff on the north side of the stream:

Section No. 5.

Base.

1.	White shales and gray colored sandstones forming bluffs	300 feet.
2.	Yellowish shales and coarse gray sandstones	100 feet.
3.	Gray sands and marls with greenish tint and having bands of limestone and sandstone. These beds weather into "bad-lands"	175 feet.
4.	Sandstones and greenish shales with bands of impure limestone near the top. These beds contain quantities of *Unio Haydeni*, and fragments of what appear to be fossilized branches, some resembling *equisetum*	100 feet.
		675 feet.

Above this section are sombre beds in which vertebrate remains are found. The lower part of the section should probably be referred to the Green River Group, while the upper beds are probably of Bridger age. Still farther up the river lower beds appear, and the cañon walls are formed by coarse gray sandstones, with yellow sandstones and greenish shales. North of Ham's Fork these beds form a bluff line facing Oyster Ridge. This will be considered again farther on.

Ham's Fork is the largest of the western tributaries of the Green lying within our district. In the early spring it is not fordable on account of the high water, and the fords are always difficult on account of the miry character of the river-bottom.

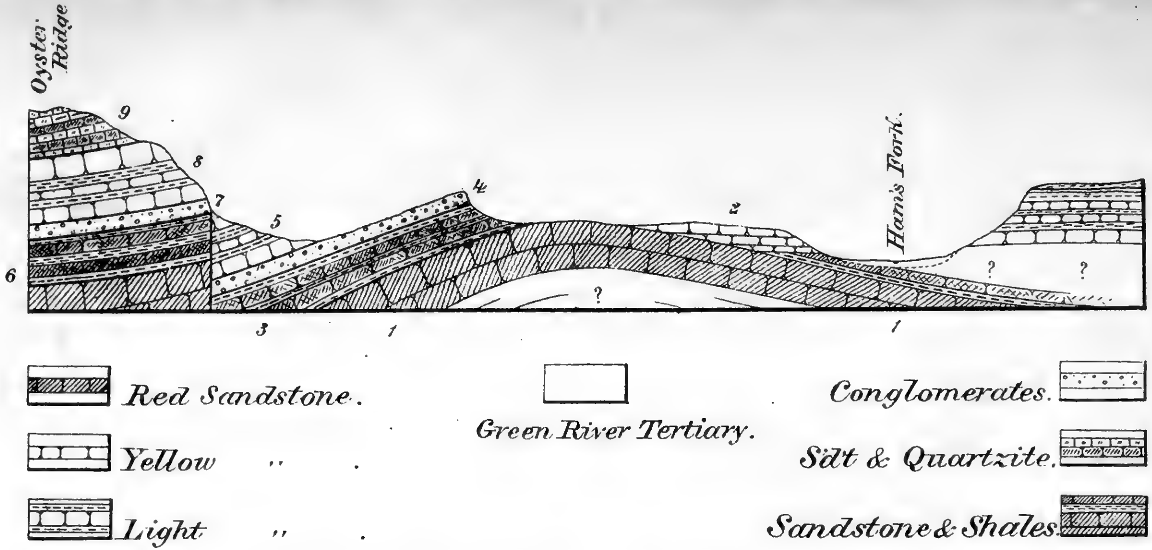


Diagram Section of Fault and Fold,
East side of Oyster Ridge.
The Figures refer to Section No, 6.

F. D. Owen. del,

OYSTER RIDGE.

In Vol. II, Descriptive Geology, Exploration of the Fortieth Parallel, Mr. S. F. Emmons describes a Cretaceous fold, forming what he has named Oyster Ridge, from the abundance of fossil remains of *Ostrea* found upon it. The culminating point of this ridge, he says, is Ham's Hill. This point lies within the district examined by us, and was our Station No. 33. What was a simple fold in the district examined by Mr. Emmons has, in the region about Ham's Hill, become complicated by a fault and a secondary fold. On the west side of this northern end of the ridge, Ham's Fork flows southward in a monoclinal valley in sandstones that are of Fox Hills Cretaceous age. On reaching the south line of our district it turns abruptly to the eastward, and cuts a cañon through the ridge at right angles to the strike of the rocks composing it. Just before it emerges from the eastern end of the cañon we have the following section, which is represented in the accompanying diagram:

Section No. 6.

1. Pink and red sandstones folded, dipping 8° to 10° on the eastern side and 25° on the western.
2. Resting on the eastern side of the fold uncomformably are soft yellow sandstones dipping east about 4°. The outcrop of these sandstones is rather obscure, and on the bluff, a short distance east of the outcrop, in fragments of sandstone that appear to belong in these strata, I obtained the following invertebrate fossils: *Campeloma macrospira, Corbula* ———? *Pyrgulifera* ———? and a fragment of a leaf which Professor Lesquereux says resembles an *Araliopsis* of the Cretaceous.
3. Purplish, reddish, and greenish sandstones and shales.
4. Conglomerate, dark in color, and somewhat metamorphosed, dip 20° to west.
5. Sandstones.
6. Same layer as No. 3, dipping west 6° to 8°.
7. Same conglomerate as No. 4, dip 6° to 8° west.
8. Sandstones, like No. 5.
9. Sandstones and quartzites of Station 32.

Above these are black shales and yellow sandstones, followed by massive sandstones, whose strike carry them through Ham's Hill. In the upper part of these sandstones, at the bend of Ham's Fork, there is a bed of coal. We have, therefore, in this cañon an anticlinal fold toward the east, with its western side faulted. Resting on the eastern side are beds that appear to be of Laramie or Post Cretaceous age. These beds do not show as we follow the eastern side of the ridge north, but appear to be covered by the red beds of the Wahsatch Group, which overlap them. Before the deposition of these layers, therefore, the ridge must have been subjected to a vast deal of erosion, especially on its eastern face, for the western members are the most important topograpically, the Cretaceous sandstones forming the mass of the ridge. The red sandstones in which the fold is so well marked in the cañon probably represent the Triassic Red beds and the conglomerate I have provisionally considered to be the No. 1 Cretaceous. Looking north from Station 33, on Ham's Hill, the sandstones of which it is composed are seen forming the Fontenelle hogbacks, which are much lower, while the continuation of the fold is distinctly noted in the Meridian Ridge. Whether the fault is continuous or not, I cannot say. In the Meridian Ridge the greatest amount of erosion has taken place on the western side of the fold, and it has somewhat obscured the relations of the rocks. As to the age of the elevation of the ridge, it is evident that it was Post Cretaceous, and that the uplift was followed by a period of erosion before the beds of the Wahsatch were deposited upon the upturned and eroded edges of the Cretaceous strata. The strike of the Fox Hills beds, which in Mr. Emmons's district is a little east of north, changes to north, and can be traced

curving to the westward a little above Ham's Hill, and after crossing a branch of Crow Creek, is seen to turn once more to the northward. The angle of the dip is about 20°.

HAM'S FORK BASIN.

Following Ham's Fork to its head, it is seen to have its sources in a basin of Wahsatch beds lying west of the southern extension of Absaroka Ridges. The extension of this basin northward, as colored on the map, is somewhat indefinite, and the relations of the beds to the older rocks in the hills on its rim are unknown. The river flows south through the basin, receiving lateral branches from both sides. On reaching the northern end of the Ham's Fork Plateau the river turns slightly to the eastward, keeping along its eastern edge. It is evident that the Green River shales once extended over the whole basin but have been eroded away. Ham's Fork Basin represents an old bay of the earlier Tertiary Lake. Whether the ancient lake whose sediments are found in the Bridger deposit, ever extended up this arm it is impossible to tell, as no remnants of it are found there now, and even the Green River Group is eroded entirely from the greater part of the basin. The bright red and pink Wahsatch beds are seen on the slopes of the Absaroka Ridge, but we were not close enough to determine the relations.

HAM'S FORK PLATEAU.

This plateau really represents that portion of the ancient arm of the Tertiary Lake just described, from which the Green River beds have not been eroded. It is a plateau, cut into mesas by four streams flowing eastward into Ham's Fork, and by the branches of Twin Creek, a tributary of Bear River, which flow southward to join the main creek, whose course is westward. It is a tongue extending northward from the western side of what is called on the maps of the 40th parallel survey the Aspen Plateau. In the southern extension, however, the capping of Green River beds appears to be absent, as there is none of the formation colored on the map. The western boundary of the plateau is an anticlinal range of Carboniferous rocks, from the sides of which the Green River Group dips slightly towards the east, rising a little as Ham's Fork is approached. The upper beds of the group here are fine-grained, compact, white limestones. Below are dark shales, that weather white on exposure to the air. In these, near Camp 21, we obtained fish remains. The thickness of the shales and limestone here is about 400 feet. The streams generally cut deep enough to expose the variegated beds, which also show on the slopes of the high hills to the westward. The cañons cut in the plateau are marked by almost perpendicular walls, on the sides of which, especially towards the heads, there are numerous springs. Running water does not extend far along the courses of the creeks. The cañon-heads are just as steep as the sides. They begin abruptly, and are the counterparts, on a smaller scale, of the cañons in the Green River Group of the Grand River Cliffs in Northwestern Colorado, described in the Annual Report of the Survey for 1876.

Associated with the fish remains found near Camp 21 (near Sublettes road), I found three leaves, which were sent to Professor Lesquereux for identification. Of them he writes me, "Of your specimens, I find in Nos. 1 and 3 the same kind of leaf of a new species of *Myrica;* in No. 2, an involucre of *Ostrya*, new species; both are referable to the Upper Green River Group, which is by the plants the equivalent of the White River Group."

On Twin Creek two brothers by the name of Bell have been blasting

out the fossiliferous shales for specimens, which they send to the railroad for sale. Prof. E. D. Cope has described a large number of species of fish from this locality.* The specimens collected by me were sent to Professor Cope for identification, and the following is the list:

Mioplosus abbreviatus.
Mioplosus labracoides.
Mioplosus (species?).
Dapedoglossus testis.
Diplomystus humilis.
Diplomystus analis.
Priscacara pealei.
Priscacara serrata.
Priscacara serrata (young).
Clastes ferox.

A few insects also were collected, and were sent to Prof. S. H. Scudder. Leaves also are found in connection with the insects and fish. They occur in a calcareous shale, which is easily cut when first taken out, so that the specimens are generally in better shape than those obtained from the shales of Green River City. In the lower part of the bluff from which these specimens are taken, the bright colored beds of the Washatch are seen outcropping, although the entire section cannot be seen, as their softness causes them to weather so that the *débris* conceals the strata. The fossils are found at several horizons in the shales. Near the top of the bluff is a band of hard, bituminous, or oily shale, which burns rather freely with a strong bituminous odor. The occurrence of this shale in connection with the fish-beds suggests the possibility of the animal origin of the oily deposit. It is brownish-black in color and on the weathered surfaces a bluish-white. Its structure is very irregular and seems to include fragments of sand. Portions are slightly calcareous, although it is mainly argillaceous.

Somewhere near the head of Twin Creek, between it and Ham's Fork, is the Mammoth Mine. The following notes in regard to it were furnished by one of the Bell brothers, who, with two brothers by the name of Smith, were the discoverers of the beds in July, 1876. The coal occurs in Bell's Pass between the head of Twin Creek and Ham's Fork. A thickness of 315 feet includes all the coal beds, of which there are twenty-nine separated by sandstones and clays. They are from a foot and a half thick to 48 feet thick. Openings have been made into each bed, but none have penetrated more than about 20 feet. The strike of the beds is about north and south, and the dip 30° or 40° to the west. There are said to be other beds outside of this that have not been opened. Nine miles farther south the same beds are said to outcrop again, but with a southern dip which throws them under the Bridger road. No fossils have been found in connection with the coal beds, but it is probable that the horizon is above that of the coal outcropping at the bend of Ham's Fork. The latter is probably in the upper part of the Fox Hills Group or the lower part of the Laramie Group. As to its relation to the coal of Evanston and the coal exposed lower down Twin Creek, nothing can at present be said. The men from whom the description was obtained think it is not the same bed. The coal appears to be of good quality with a good luster, and does not seem to be much affected by the weather. I was also shown specimens of a softer coal from layers that were said to rest uncomformably on the beds containing the mammoth beds.

---

*Bulletins U. S. Geol. Survey, vol. iii, No. 4, p. 807; vol. iv, No. 1, p. 67.

ABSAROKA RIDGES.

West of the Fontenelle Hogbacks and east of Ham's Fork Basin is a plateau-like ridge of Carboniferous beds, which, when followed to the northward, develops into several parallel ridges, and finally culminates in the Wyoming Range. Only that portion lying between Ham's Fork Basin and the Hogbacks was visited. Two stations, Nos. 25 and 26, were made on this plateau-topped ridge. Quartzites form the summit dipping to the westward, and below the summit limestones outcrop with fragments of *Zaphrentis*. The summit is well timbered. Looking north all the dips appear to be toward the west. What the rocks are, however, it is impossible to say definitely, but the strikes of Station 25, carried north, would seem to indicate them to be of Carboniferous age, with perhaps later beds northwest. I am equally uncertain about the south end of the ridge, and the relations of the overlying Wahsatch beds on the west on Ham's Fork. On the east there is a rather abrupt bluff face, and a short distance east in the valley beds of sandstone and limestone with *Ostrea soleniscus* are found, also dipping westward, seeming to abut against the westward-dipping Carboniferous limestones. There is probably a fault extending along the eastern side of the range, but the junction is so covered by *débris* that it can only be assumed.

MERIDIAN RIDGE.

Extending southward from Thompson's Plateau to Slate Creek is an anticlinal uplift, meridian fold, that forms the western rim of the Green River Basin at this part of its extent. This ridge was crossed by us at two points only, viz, south of Fontenelle Creek and near Slate Creek. The highest portion of the ridge is north of Fontenelle Creek, where an elevation of about 8,000 feet is reached. Labarge Creek cuts a cañon through the north end of the ridge. The upper portion of the ridge not being visited, of course its description is not attempted. It is probable that Carboniferous and Jurassic rocks form the main part of it, and it has been so colored. Approaching the ridge *via* Fontenelle Creek the Green River Group is seen to terminate in a bluff facing the ridge, with its strata inclining gently towards the eastward. From beneath these strata the Wahsatch beds appear abutting against the more steeply inclined older beds that form the fold which makes the ridge. At the Fontenelle the trend of the ridge is about due north and south. Towards Labarge Creek it is little west of north. The following section was made on the western slope of the ridge south of Fontenelle Creek. The edges of the strata face the west, the strata being almost horizontal on the summit, but dipping steeply to the eastward on the east side of the ridge.

Section No. 7.

Top.		
6.	A reddish quartzite, thin and without fossils. It forms the summit in some places and is entirely eroded away in others	100 feet. (6–4)
5.	Bluish limestone containing *Pentacrinus asteriscus*, *Ostrea strigulecula*, *Camplonectes bellistriatus*, *Mytilus* ——? *Myalina* ——? *Modiola* ——? *Trigonia* ——? *Ostrea* ——?	
4.	Reddish sandstone	
3.	Bluish limestones, laminated and blue argillaceous shales and slates	150 feet. (3–2)
2.	Bluish and gray limestones	
1.	Reddish quartzites which appear to reach to the valley of the creek to west of ridge. They are much broken and appear to have been abruptly folded. The distance to the creek level is about	600 feet.
	Total	850 feet.

In the cañon limestones probably outcrop, and if the quartzites (No. 1 of the section) are Triassic, as I believe, the limestones would be of Carboniferous age. Professor Cope visited the cañon and recognized Carboniferous rocks.* "In one of the Carboniferous strata," he says, "I found a well-marked horizon of Carbonaceous shales extending as far as I explored them." The erosion that has excavated the valley at the west side of the ridge has therefore cut into a portion at least of the Carboniferous. The ridge is therefore an anticlinal with the sharpest portion of the fold on the western side. This is the portion eroded away. Erosion has considerably obscured the beds, and at one time I thought it probable a fault extended along the ridge, especially as a fault was noticed west of the fold at the cañon of Ham's Fork. The latter fold is the southern continuation of the Meridian Ridge. The valley between Meridian Ridge and Absaroka Ridge is occupied by the Fontenelle Hogbacks. The view from the former ridge is thus described by Professor Cope in the report for 1872: "From the summit we have had a beautiful and interesting view of geological structure. The valley, of three or four miles in width, is bounded on the west side by a range of low mountains (*Absaroka Ridges*), whose summits are well timbered. The valley is excavated at an acute angle to the strike of the strata, so that as far as the eye can reach to north and south successive hogbacks issue *en echelon* from the western side and run diagonally, striking the eastern side many miles to the southward."

The hogbacks, south, are not as numerous, because the fold of Meridian Ridge is not so elevated, and the greater part of the beds curve over and are found on both sides preserving the anticlinal. At the head of Slate Creek I could find no evidence of any fault. The Wahsatch beds extend farther to the westward below Slate Creek, so that the Jurassic beds do not appear and the character of the ridge is completely lost.

FONTENELLE HOGBACKS.

These hogbacks have been partially described under the preceding head, as they are formed by the western members of the Meridian Ridge fold. They extend northward from Ham's Hill into the valley of Labarge Creek. They are most marked on the Fontenelle, and hence their name. A section carried across the valley or depression in which they outcrod is in general as follows:

Section No. 8.

Base.

1.	Shales and limestones, with bands of sandstone. The lower beds dip 5° to the westward, and the upper beds 8° or 9°. The thickness, as estimated, is about	500 feet.
2.	Above the layer No. 1 follow sandstones, with pink and gray shales above, which are yellow sandstones. The dip in these beds is 10° to west	900 feet.
3.	Yellow siliceous sandstones, forming well-marked hogbacks, dip 10°	500 feet.
4.	Space probably filled with sandstones and limestones, dipping 5° to 18° to west. In these is a bed full of *Ostrea soleniscus*. Thickness	1,000 to 1,500 feet.

Some of the shales in larger No. 1 resemble those of the Colorado Cretaceous; but I could find no fossils, and failed also to recognize the Dakota Group. My time, however, was limited, and Professor Cope informs me that he obtained Cretaceous fossils from some of the shales at a point somewhere in this neighborhood. It is probable, therefore, that the whole Cretaceous series is present. The beds, with the *Ostrea*, are un-

* Report U. S. Geol. Survey, 1873, 1874, p. 440.

doubtedly the Fox Hills Group, and the sandstones in layer No. 3 may represent the Fort Pierre Group (Cretaceous No. 4).

The Fontenelle comes from the north on the west side of the principal hogbacks until joined by a stream rising in the Absaroka ridges, where it turns towards the east and cuts across the hogbacks, flowing in a zigzag course, now across and now with the strike, until it reaches the head of the cañon. Following southward through the trough-like depression between the hogbacks and the Absaroka Ridge, we come to Crow Creek, a branch of Ham's Fork. This stream flows southward west of the principal sandstone hogback. Just outside of this sandstone ridge, where the road from Slate Creek comes to the stream, I found an outcrop in which the following fossils occurred in a bed of soft sandstone:

Ostrea soleniscus.
Ostrea ——— ?
Trapezium ——— ?
Inoceramus ——— ?

This layer I am inclined to think lower than the one from which *Ostrea soleniscus* was obtained on the Fontenelle, although I cannot be certain. The hogbacks at this point are much lower and the inclination less than on the Fontenelle. The hogbacks farther south, however, assume greater proportions in the ridge of Ham's Hill, and a small ridge in which there is a coal-bed shows to the west of the latter. Farther north I saw no evidences of this coal-bed, but the outcrops were so indistinct that it might easily be concealed by the débris, and I did not have time to make a close detailed section at either of the points where the hogbacks were crossed. The Fox Hills beds are seen abutting against the Carboniferous limestone. Either there is a fault on the west or the hill in which these limestones outcrop was a shore line during Cretaceous times. This subject, however, will have to be deferred to a future chapter.

Looking north from the Fontenelle, the hogbacks are seen filling the valley of Labarge Creek. Some of the branches of the latter stream rise 7 or 8 miles south of the point where the Fontenelle emerges from the Absaroka ridges, and have their valleys parallel to that of the latter, although they flow in the opposite direction. On Labarge Creek the trend of the hogbacks turns toward the west, and they become much less prominent as viewed from Thompson Plateau, the nearest point from which they were observed.

THOMPSON PLATEAU.

Viewed from the Green River Basin, the edge of this plateau presents a very regular outline. It is about 10 miles in length and from 2 to 3 miles in width. Only one station (No. 47) was made on it, and that was on the northern end. It is composed of massive limestones dipping to the west. Fragments of *Zaphrentis* were the only fossils. North from the plateau there is an anticlinal fold that is on the direct line of the fold of Meridian Ridge. It is probably the same fold, and I have called it Meridian fold. At Station 47 the fold appears to be a monoclinal, and the limestones appear to be connected with those on the west side of Meridional Valley. Station 46 was on the axis of the anticlinal, but the beds were concealed. The fold, however, could be distinctly seen on the north side of the cañon of Piney Creek, and the section in an accompanying plate gives the relations of the beds as noted. I am in doubt about the gray beds in the centre, as no fossils were obtained.

Their age must remain doubtful until a section in the cañon of the Piney is made. The sandstones forming the upper portion of the section are undoubtedly the Laramie sandstones; for, on a branch of the Piney, only a little farther north, I obtained Laramie fossils. The relation of the fold to the plateau could not be definitely determined. The simplest solution appears to be that the plateau represents the highest portion of the elevation, and that in the fold north the overlying beds have not been removed, but that Jurassic and Cretaceous layers are still preserved. This supposes a vast erosion subsequent to the uplift; for, on the east of Thompson Plateau, the Wahsatch beds rest on the Carboniferous limestones extending to the eastward in long, smooth slopes, while at the cañon they rest on the more modern beds, whether Jurassic or Cretaceous I am unable to say. It is probable that Cretaceous is present, as there is room for a thickness of 7,000 feet of beds between the axis of the fold and the range to the westward.

MERIDIONAL VALLEY.

Between the rim of the Green River Basin and the Wyoming Range is a deep, trough-like depression, which, as far as could be determined by the few fossils that were found, is filled with sandstones of the Laramie Group. The structure of this valley will be apparent by glancing at the sections across it represented in the accompanying plate, showing sections of Meridian fold. The valley extends from the Piney, north of Thompson Plateau, to Marsh Creek Valley. The branches of the Piney, Bitterroot, and Marsh Creek drain the region with north and south courses, while the main streams flow eastward. The rim of the basin is an anticlinal, which is represented in the sections. In this anticlinal no rocks older than the Jurassic were observed. On the north side of the main Piney the steepest side of the anticlinal is the eastern, the dip of the beds being 80° on that side as seen beneath the unconformable Wahsatch beds. The western side dips west 50°. The lower beds are probably of Jurassic age, as determined by fossils found farther north. They were seen from a distance at this point, and consist of gray beds, probably limestones. Above them a reddish limestone outcrops, followed by sandstones and shales, and again white sandstones with greenish-gray laminated sandstones still higher. There is room in the section for 7,000 feet of beds, and the whole Cretaceous system is probably present, although not positively identified. The dip of the beds on the west side of the anticlinal is south 77° west. In the range to the west the dip is westward. On the east the variegated Wahsatch beds rise on the ridge so as to cover the greater part of the eastern side of the anticlinal. They dip 6° to the eastward.

On a small branch of the Lake Fork of Piney Creek, east of Station 48, I found a *Corbula*, and other indistinct fossils. On the north side of the main Lake Creek the following were obtained: *Pentacrinus asteriscus* and *Neritina* ——? The angle of dip here on the western side of the anticlinal is about 25°, as shown in the section. There appear to be quartzites in the centre of the fold, but whether they are the representatives of the Red Beds or not, it is impossible to say. The fold at this point is much more gentle than on the main Piney. The section on the south side of Bitterroot Creek shows the fold to be still more gentle, the western members showing dips of 20°. The eastern side is still the more abrupt, and the Wahsatch beds still conceal the greater portion of it. North of the Bitterroot the Wahsatch beds cover the axes of the fold entirely, and present a bluff face to the westward. On top the beds are

covered with the débris of the range to the westward, composed of limestone and quartzite pebbles. Underneath are the following beds:

Yellow sands and conglomerates.
Red marls and sands.
Purple sands and conglomerates.

These beds are 500 to 600 feet thick, and dip slightly to the eastward. The conglomerates are composed of quartzite and limestone pebbles and bowlders, evidently derived from the range that lies to the westward. Some of the limestone pebbles contain indistinct fragments of Carboniferous fossils. On the top of the plateau which these beds form I found *corals* and a *Spirifer* in some of the pebbles. I think these pebbles were derived from the weathering of some of the upper conglomerates. The bluff of bright colored conglomerates extends from the Bitterroot to Lander Creek. Between Lander Creek and the main branch of Marsh Creek the anticlinal again shows. On the ridge here Station 51 was located, on a hard limestone containing remains of a small *gasteropod* that is probably of Jurassic age. As seen from this point, the beds north of Marsh Creek are more folded than was noticed at any point south. The strike is about north 13° west. There were three anticlinals, all rather gentle; west of the most western the dip of the sandstones was 30°, and next to the Carboniferous Range an angle of 20° was noticed. Between these two points, however, the beds are nearly horizontal, as shown in the section. The Wahsatch beds rise on the hills on the east side, and remnants are seen resting on the upturned edges of the sandstones on the west side. These sandstones are greenish-gray, and laminated in character. No fossils were found in them. They have been colored on the map to represent the Laramie Group, as the only fossils found in their southern extension seem to indicate that as their age. The area between the anticlinal and the Wyoming Range is wider from Lander Creek northward than southward. Marsh Creek rises opposite the head of McDougal's Creek, in a basin of sandstones which present bluffs on the head of the latter. The divide between the two streams is on the east side of the Wyoming Range. Another case similar to this occurs at the head of a branch of John Day's River; the divide between them being some distance to the east of the range. Another case occurs farther north, on a much larger scale. This was just north of our line, and will be the field of future exploration.

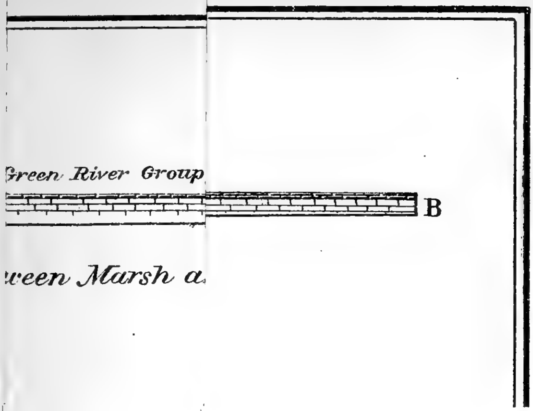
WYOMING RANGE.

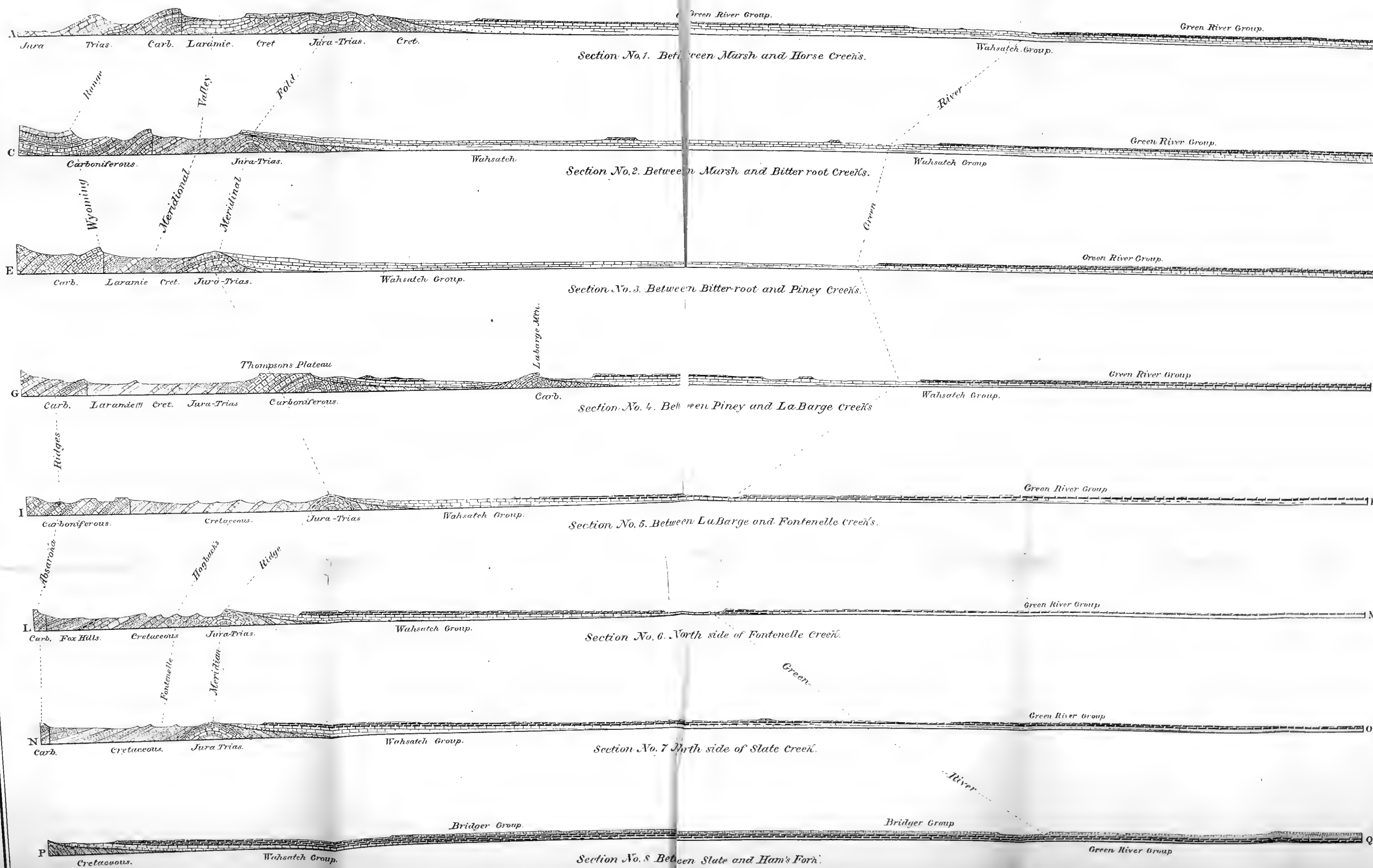
I take up this range in this chapter inasmuch as the greater part of its drainage is to the eastward into Green River Basin. It is about 35 miles long in our district from Thompson's Pass to our north line. Beyond the latter it reaches to the Gros Ventre Range. The width is from 6 to 8 miles. The peaks range in elevation from 10,000 to over 11,000 feet. Wyoming Peak, on which station 55 is located, is the highest peak, having an elevation of 11,490 feet.

Towards the Green River Basin the range presents a rather abrupt face, with basset edges of limestone strata which dip to the westward from 10° to 20°. These limestones have been colored to represent the Carboniferous, as only carboniferous fossils were found. There is an exposure of from 2,000 to 8,000 feet of beds, and it is possible that the lower portion ought to be referred to the Silurian or Devonian.

At station 48 the following is a general section.

Plate LIII.





For lines see Maps Plates No. L and LI.

SECTIONS ACROSS THE GREEN RIVER BASIN.

F. D. Owen, del.

Section No. 9.

Base.	
1. Massive blue limestones reaching from the base of the cliffs to a point about 1,600 feet above; thickness about	2,700 feet.
2. Red limestone	} 800 feet.
3. Blue limestones, with crinoidal stems; indistinct *corals* and fragments of an *Archimedes?*	
4. Quartzites	} 1,400 feet.
5. Blue and yellow limestones	
6. Quartzites on station 48	
	4,900 feet.

The lower layers have a very old look, and are in all probability Sub-carboniferous, although they may be Devonian or Upper Silurian. The dip of the strata is about 20° to the westward.

Station 55, or Wyoming Peak, is almost due west of station 48. It is, however, on higher beds that represent the Trias formation.

The following section was made on the peak:

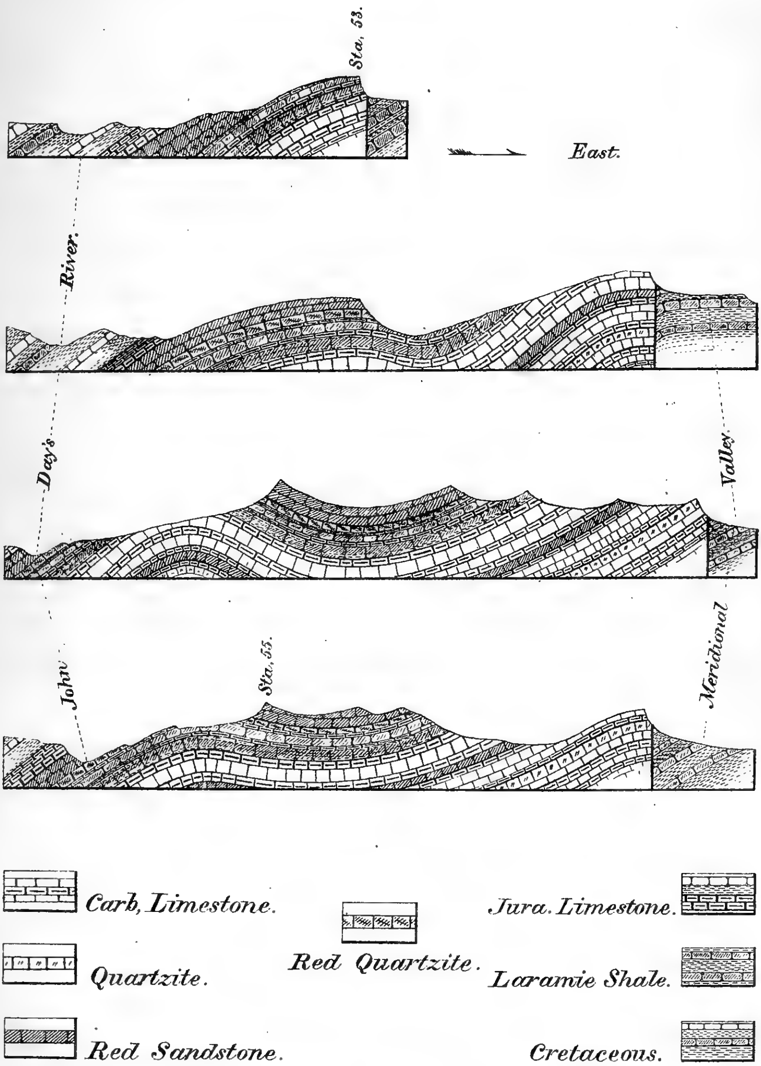
Section No. 10.

Top.	
10. Red quartzitic sandstones forming summit of the peak about	110 feet.
9. Red sandstones with quartzitic and shaly bands	} 60 feet.
8. Light brick-red colored sandstones	
7. Mottled *calcareous* sandstones	
6. Purplish limestones with mottled layer	} 150 feet.
5. Bluish and purplish quartzites	
4. Red sandstones and shales	350 feet.
3. Bluish limestones	250 feet.
2. Dark quartzites	} Not taken.
1. Conglomeritic sandstones	
Total	920 feet.

These beds are almost horizontal and tongues run out to this eastward from the crest of the range onto the spurs. Between this section and the section of station 48 there must be from a thousand to fifteen hundred feet of beds that probably represent the Carboniferous coal measures. Northward from the station there appears to run a synclinal depression. It is rather shallow, and not very broad. It is probably the same one that will be referred to again as occurring on McDougal's Creek.

Station 49 was located on a limestone ridge that appeared to stand out to the east from the main range. The dip of the rocks is here more to the southward. On the summit a quartzite outcrops, and below it are blue limestones, followed, as we descend, by yellow limestones. The quartzites are probably the same as those of layer No. 5 in the section made at station 48. The view as we look southwest into the main range shows a confused mass of high peaks in whose recesses lie huge snow-banks. The synclinal, north of station 55, can be distinctly traced, and at this point it appears to be broader than at any other. This has preserved a greater body of the Red Beds (Trias?), and we found that the water on Lander Creek, from their erosion, had a red tint not observed on the other streams. A succession of quartzites and reddish sandstones with interlaminated gray beds could be seen dipping west at an angle of about 30°. Station 49 was named by us Mount Lander, after a civil engineer who traversed a large portion of this region on surveys for a wagon road across the country. There are two passes across the Wyoming Range within the limits of our district, viz, Thompson's Pass and McDougal's Gap. The former is the one by which the Lander Cut-off road crosses, and is at the southern end of the range. McDougal's Gap is about 25 miles farther

north, and is the route of a broad and well worn Indian trail which follows up Marsh Creek. The ascent is very gradual to the rim of a small basin in which McDougal Creek heads. This is at the eastern base of the range. The descent from the head of Marsh Creek to the head of McDougal's Creek is very abrupt, and the latter stream has a rapid descent through a narrow and rough cañon. Gray laminated sandstones dipping to the westward at an angle of 20° are first crossed. These abut against the edges of limestones, which also dip to the westward. The angle of inclination in the limestones at first is 10°, but this increases to 25° as we go down the cañon. Reaching a creek coming from the north a few miles west of the Pass we find beds flattening out until we soon cross a gentle synclinal and shortly afterwards an anticlinal fold. This latter fold is continuous along the western side of the range. The creek already mentioned as coming into McDougal's Creek from the north cuts the range into two ridges that are parallel to each other. The eastern or outside ridge is composed entirely of limestones and quartzites of Carboniferous and perhaps Silurian age. The western ridge continues the main crest northward, while the eastern ends at a point east of station 53. The latter was our most northern station in the range, and was on limestones whose position was almost horizontal. Going westward, however, this dip soon becomes 35° or 40°. To the south and to the north the Red Beds (Trias) are seen reaching up on the summits of the ridge. In the valley of John Day's River opposite the station and for some distance north of McDougal's Creek the fold of the Red Beds on the western side of the range is preserved; but farther south the fold is more abrupt and the line of sharpest folding is most eroded, so that on the summit of the range we have the Red Beds resting in almost horizontal position on the Carboniferous limestones, and in the valley of John Day's River they dip 25° to 35° to the westward. Between these two there is a gap in which only Carboniferous shows. This portion of the range, in consequence of this erosion, presents a rather steep, bluffy face to the westward. The summit of the range is about a mile and a half east of the valley, above which it rises nearly 4,000 feet. The upper portion is an almost sheer precipice in most places. South of Thompson's Pass the Absaroka Ridges continue the line of the range, gradually diminishing in height towards the south. These have already been considered.



SECTIONS

ACROSS THE WYOMING RANGE.

F. D. Owen. del.

CHAPTER IV.

DESCRIPTIVE GEOLOGY—SNAKE RIVER DRAINAGE AREA.

John Day's River—Salt River Range—Salt River—Blackfoot Basin—Portneuf River—Marsh Creek—Portneuf Range—Bannack Range.

In the present chapter, I shall take up the general geology of the branches of Snake River that drain the northwestern portion of the district. As there are alternately streams and mountains, in general parallel to each other, I shall take them up in order from east to west instead of considering the drainage system first and the mountain ridges and ranges afterward, as was done in the preceding chapter. I shall endeavor, in taking up each stream and range, to give a general idea of the geological structure of the immediate region as determined by the facts noted by us. These, however, must be necessarily incomplete. The whole region is one admirably adapted to rapid topographical work, while the geology is complicated, especially in the ranges. The general structure was well determined, but there are many detailed points still to be worked out, and a geologist will find much to interest him for a long time, especially in the Salt River Range and in the Preuss Range.

The branches of Snake River draining this portion of the district are John Day's River, Salt River, Blackfoot River, and the Portneuf River. Salt River Range is the highest mountain range. Other ranges are the Portneuf, Bannack, and the northern spurs of the Preuss Range.

JOHN DAY'S RIVER.

John Day's River has a length of about 35 miles within our district. Its course is about due north to within a couple of miles of our north line, where it turns to the northwest. The river was named after one of the early trappers of this region. Its extreme head is in the southern end of the Wyoming Range, between La Barge Creek and the branches of Piney Creek. Its valley is narrow and cañon-like throughout its length, and the hills sloping to it are well timbered with pines. The stream is clear and rapid, generally difficult to ford. Geologically the valley is a monoclinal cut in rocks of Jura-Trias and Cretaceous age. Opposite Station 55 the river flows over the red quartzitic sandstones that lie just above the limestones of the Wyoming Range. They outcrop on both sides of the valley, dipping 35° or 40° to the westward. The Wyoming Range on the east side of the river presents an almost vertical face toward the valley. The summit is capped by "red beds" in almost horizontal position. Below the red sandstones are conformable limestones, which, as we get nearer the level of the valley, curve and dip conformably beneath the red sandstones that form the hogback-like ridges on its east side. The projecting angle of the fold has therefore been eroded away. In the valley the river winds but little. A couple of miles above Station *b* the river turns slightly to the eastward out of the red sandstones, but soon turns westward again, cutting across the red sandstones into the gray Jurassic beds that lie above. The stream

here cuts quite a deep cañon, from which it emerges into the broadest valley along its course. This valley extends northward about six miles, to the mouth of McDougal's Creek. It is nearly a mile wide in the widest part, and near the lower end the river includes quite a large island. The valley is covered with a growth of sage interspersed with good grass. The red sandstones outcrop on the east side until within about a mile of McDougal's Creek, when the gray Jurassic limestones cross from the west side about opposite the lower end of the island. The river here bends to the westward, and thence northward appears to be in a monoclinal of Jurassic rocks.

Station *a* was located on quartzite on the north side of McDougal's Creek, opposite its mouth.

Station *b* was located on red quartzitic sandstone, on the east side of John Day's River, about five miles south of Station *a*. Near Station *a* the sandstones outcrop at the angle of McDougal's Creek, about a mile and a half above its mouth.

Between the two stations they rise on the western slope of the Wyoming Range. At one point the fold in these red beds is unbroken. They appear to be horizontal on the summit of the range.

Between Station *a* and the top of the red beds exposed to the eastward at the angle of the creek there is exposed about 1,500 feet of conformable beds dipping to the westward 25° to 30°.

The following is the section at this point:

Section No. 11.

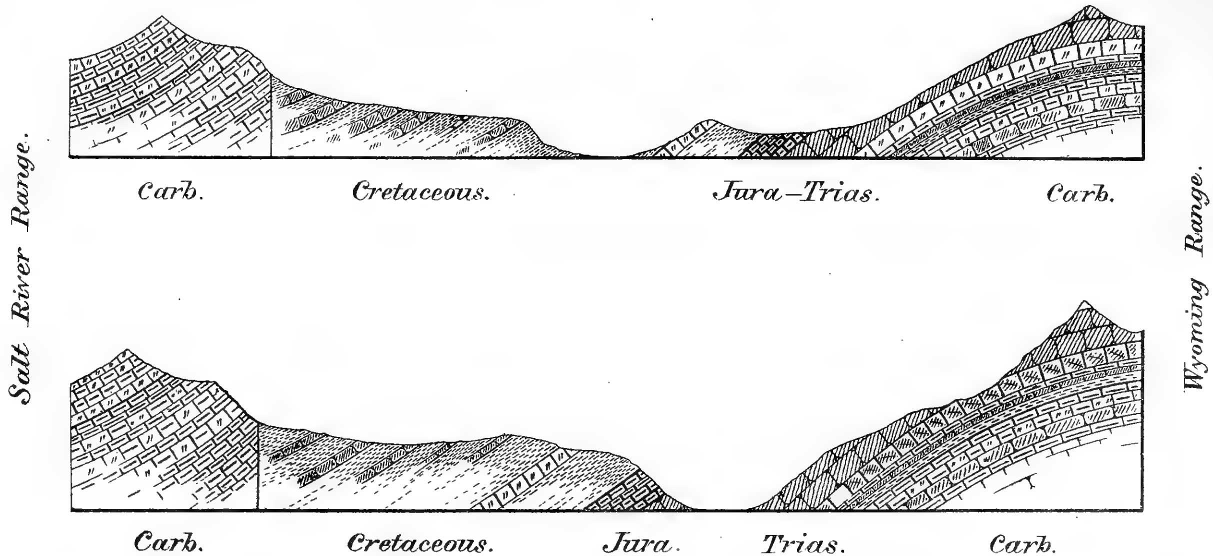
Top.

1. Quartzite.
2. Reddish arenaceous shales.
3. Green laminated sandstones.
4. Greenish-gray limestones with very irregular structure. Some of the layers appear to be arenaceous. The following fossils were obtained: *Belemnites densus, Aviculopecten Idahoensis* (?) *Gryphœa,* and other undetermined *bivalves.*
5. Reddish and gray shales and sandstones.
6. Gray limestones and shales, near the top of which are *Pentacrinus asteriscus,* &c.
7. Blue laminated limestones with *Pentacrinus asteriscus, Camptonectes Cellistriatus, Trigonia,* sp.? and *Myacites,* sp.?

The thickness of this section is about 1,500 feet. Below are the red beds, of which the best section made is the one at Station 55 (No. 10).

Bed No. 1 may represent the base of the Cretaceous, but no proof was found. West of John Day's River is a thickness of from 2,000 to 4,000 feet of beds, mainly shales and sandstones, as observed in the very few outcrops seen. They appear to abut against the limestones of the east side of Salt River Range, although the line of junction was not seen at any place. The Salt River Range was crossed at only one point. These shales and sandstones have been colored on the map to represent the Cretaceous formation, from the fact that, tracing the outcrops southward, they appear to be the direct continuation of the Cretaceous beds noted on La Barge and Fontenelle Creeks.* Following down the river from McDougal's Creek we found the red sandstones forming hogbacks on the east side. The dip of these beds increases towards the north. West of Station 53 the angle is 43°. The strike of the beds is a little west of north, while the river flows directly north. The Jurassic beds outcropping at the mouth of McDougal's Creek therefore soon cross to the

* During the explorations of 1878, Cretaceous fossils were obtained in beds on Hoback's River, directly north of this valley, in about the same relative position with regard to the Jurassic.



Sections across Valley of John Day's River.

west side of the river, where they form gray and reddish bluffs as far north as the abrupt westward turn in the river.

Four or five miles northwest of Station 53 the Wyoming Range is cut by a stream flowing a few degrees south of west. From the mouth of this creek the course of John Day's River is west for about a mile and a half, when it turns northwest, a course that it holds to its mouth. On the north side of this tributary stream a good section of the strata is seen, as viewed from Station 53. Toward the east, the limestones, the basset edges of which face the Green River Basin, are seen dipping a little south of west 35°. Above the limestones are red sandstones and quartzites, and still higher lighter colored red sandstones, inclining about 25° in the same direction. Above the latter are the gray limestones and shales, in which the angle is from 20° to 25°. The entire thickness of the beds is between 9,000 feet and 10,000 feet.

The following section agrees with the section given in the illustration:

Section No. 12.

		Feet.
Carboniferous	1. Yellow limestones and quartzites 2. Blue limestones somewhat laminated near the top	2,100
Triassic?	3. Reddish sandstones and quartzites, light colored near the base 4. Red sandstones	3,600
Jurassic	5. Gray and blue limestones 6. Bluish and gray limestones, with shales and sandstones near the top. (Beds of section at McDougal's Creek come in this section here)	3,300
Cretaceous?	7. Sandstones and shales, gray and greenish 8. Yellow sandy shales? 9. Variegated reddish and grayish shales	
		9,000

It is probable that a careful detailed examination of these beds would determine the presence of the whole Cretaceous series to the top of the Fox Hills Group. The section given above is only general, and the thicknesses are approximate. They are obtained by taking the dip of 35° for the limestones, 25° for the red beds, and 20° for the Jurassic strata. Taking the average dip at 25° for all, we get a thickness of 8,000 instead of 9,000 feet.

The western side of the valley of John Day's River is a high plateau of Cretaceous (?) rocks. It is from two to four miles in width, and slopes gently from the Salt River Mountains to a bluff facing the river bottom. This bluff is from 400 to 600 feet in height in the upper part of the valley, and increases to about 800 feet above the mouth of McDougal's Creek. In this portion the plateau is much cut up by the branches of the river.

SALT RIVER RANGE.

This range is one of the most complicated within the limits of the district, especially towards the southern end, where it merges into the commencement of the ridges that continue southward from this range and the Wyoming Range. Geologically, the direct southern prolongation of the Salt River Range is found in the range that forms the divide between the tributaries of Bear River and Smith's Fork and the branches of Ham's Fork. The Salt River Range proper, from Smith's Fork northward, has a length in our district of about 35 miles. It probably extends 5 or 6 miles farther to the Cañon of Snake River. It is rough and rugged, but not heavily timbered. There is but one pass across it,

and that is McDougal's Pass. This is very high, reaching almost to the summit of the range. When we crossed, about the middle of July, we found the gorge at the head of the creek, on the west side of the pass, entirely filled with an immense snow-bank, reminding one of a glacier. Whether it is or not could not be positively determined, as the snow obscured everything. It extended for several miles down the gorge. On a creek coming southward from back of Virginia Peak a similar snow-bank was noted. On its surface were rocks and earth, and at the bottom a mass of detrital matter resembling a small terminal moraine. It seems probable that this snow remains throughout the entire year. Whether there is any motion in these snow-banks I do not know. They may be simply compacted *névés*. It is very improbable that they are glaciers. A broad Indian trail crosses the pass, following up Sickle Creek from John Day's Creek, and thence down Glacier Creek into the valley of Salt River.

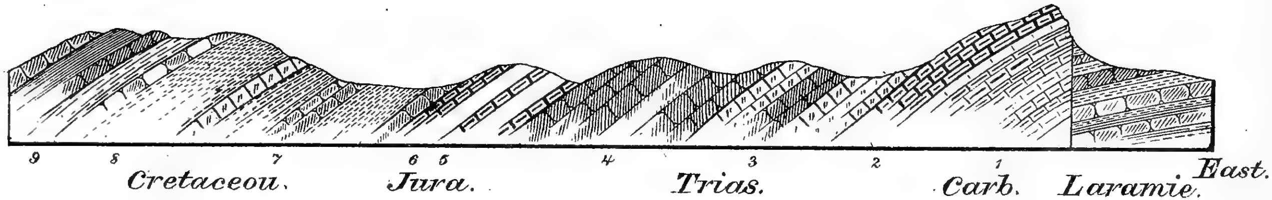
Between the head of the first creek south of Sickle Creek and Mount Wagner the trend of the range is about north and south. North of this point it bends a little to the westward. In this southern portion of the range there is a rather steep front on the east side, and from this spurs extend toward John Day's River, with bluff faces at the ends between the streams. The latter head against the main crest, back of the bluffy spurs. North of Sickle Creek these bluffy spurs have the dignity of a range, forming an unbroken crest, facing the valley of John Day's River, with steep slopes. The trend of this range is north 15° west, and the beds dip south of west. Virginia Peak is an outlying spur of this sub-range towards the north end. A station was made on it by Mr. J. E. Mushbach, who reported the rocks to be limestones, dipping south of west, but at what angle he was unable to tell. The line of junction between the limestones and the deposits in the valley was obscured by the *débris* from the mountains, as at all other places along the east side of the range. He found quantities of fossils, among which Professor White has identified the following:

Spirifer striatus.
Spirifer (Martinia) planoconvexus.
Zaphrentis ——— ?
Fenestella ——— ?
Glauconome ——— ?
Spirifer ——— ?
Rhombopora ——— ?
Chonetes ——— ?
Syringopora ——— ?

These fix the age of the strata as Carboniferous beyond doubt.

It is probable that a fault extends along this eastern side of the range. The range has been uplifted with a force that has thrown its component rocks into the sharpest of folds. If not a fault we would have to suppose the uplift to have taken place in Pre-Cretaceous time, which is not at all probable. The regular front presented by the range also impresses one with the fact of the presence of a fault.

At the head of Sickle Creek, in limestones that are cherty, I found good specimens of *Productus multistriatus*. They occur in blue limestones just above a layer of quartzite. The structure here is somewhat obscure, but I think the head of Sickle Creek is on the line of an anticlinal fold which continues southward, soon becoming very sharp, and with the eastern side of the fold removed and perhaps complicated by a fault. This is rendered probable from the fact that Glacier Creek has



Section North of Station 53.

Figures refer to Section No, 12. page 545.

F. D. O.

its head opposite Sickle Creek, and flows directly north in a cañon-like valley, which is on the line of what would be the fault, if extended. Opposite the pass the crest of the range is the edge of a monoclinal fold, or what appears to be a monoclinal, for at this point there may be an obscure anticlinal, of which the upper members of the eastern half are removed. The western members present a bluff face about 400 to 600 feet high, in which is the following general section, beginning at the base:

Section No. 13.

1. Black shales.
2. Massive limestones.
3. Interlaminated limestones and shales; some of the latter are probably arenaceous.
4. Reddish limestones and shales.
5. Interlaminated limestones and shales, like those of No. 3, but probably more arenaceous.

At the base of layer No. 2 occurs *Productus multistriatus*. It is this layer that preserves the fold just east of the range. East of this the upper bed appears to be a quartzite, and below it occur the fossils found at Virginia Peak. The fold is gentlest and broadest just south of Sickle Creek. On Station 56 the beds are steeper in their dip than at the pass. The following fossils were obtained in the beds of the section just given, occurring in layers 3 and 5:

Aviculopecten pealei, n. sp.
Gervillia, sp. ?

These are identical with species obtained from near Station 66, which have been identified as Lower Trias.

At the bend of Glacier Creek as we look north, the quartzites that cap the ridge running south from Virginia Peak appear to abut against the limestones of the main range, which are here folded into a very sharp anticlinal. The creek cuts directly across this fold. The dip of the quartzites east of the anticlinal is about 30° towards the west. The eastern side of the anticlinal dips eastward 80°. As we approach the centre of the fold, this angle diminishes to 75°. On the west side the dip rapidly diminishes to 25°, and the creek soon crosses a rather broad synclinal. The rocks are massive limestones, some containing fragments of *zaphrentis*. Before leaving the cañon the stream crosses another anticlinal that is sharper than the first. The western members of this fold pass under the valley of Salt River. The section in the accompanying figure gives the structure of the range at this point. It represents a sharp fold at the east with the beds dragged rather than faulted. The latter was not actually observed at any point near here, and a fold was noted at several places. This, however, was the only point at which the range was crossed. Two stations were made in it, one to the south of Glacier Creek and the other north of it.

Station 57 is located about eight miles north of Glacier Creek, just above the north line of our district. To reach the station from Salt River Valley, we cross the upturned edges of massive blue limestones that form a rather gentle fold along the western side of the range. On Station 57 the beds are almost horizontal, dipping slightly to westward or rather somewhat south of west, as the trend here is west of north. This is, therefore, the west side of the same anticlinal noted on Glacier Creek, near Salt River Valley. Here, however, it is much broader.

According to Professor Bradley (Report United States Geological Survey for 1872, p. 269) the valley of Snake River, below the mouth of Salt River, is located by an anticlinal fold. This is probably the northern

extension of the fold of the west side of the Salt River Range. It was impossible to determine from the station whether or not the sharp eastern anticlinal extends northward or not; but the topography indicates that if it does it becomes gentler. John Day's River may occupy its axis. The cañon of Snake River is only thirteen miles north of Station 57. Professor Bradley passed through this cañon in 1872, and says that three anticlinals are crossed, in the third of which (the most western) there is considerable displacement. The investigations of Mr. St. John in the region north of Snake River will probably throw some light on the structure of the northern portion of the range. All the rocks exposed in this portion of the range are probably of Carboniferous age; at least nothing more modern appearing north of Glacier Creek as far as Station 57.

The sequence of the rocks at Station 57 is as follows, beginning at the west and going down:

Section No. 14.

1. Massive blue limestones, with fragments of *corals*, and an indistinct spirifer.
2. Blue limestones, weathering light-yellow, with light bands.
3. Blue and yellowish limestones, in rather thin bands that are highly fossiliferous.
4. Dark-blue limestones.
5. Yellowish limestones, with perhaps bands of quartzite. These beds were seen only from a distance.

Layer No. 4 or No. 5 may possibly be the equivalent of the fossiliferous horizon of Virginia Peak. Layer No. 3 represents the limestones outcropping on the station, about 150 feet in all, and containing fossils at five horizons or layers, as follows:

At the top, on layer 1, we have—

Hemipronites crenistria.
Euomphalus ——— ?
Platycrinus ——— ?
Zaphrentis ——— ?

In layer No. 2, 50 feet lower down, occur—

Hemipronites crenistria.
Spirifer ——— ?
Murchisonia ——— ?
Synocladia ——— ?
Productus ——— ?
Euomphalus ——— ?

In layer No. 3, 40 feet below No. 2 and 90 feet below the summit of the station, the following occur:

Murchisonia ——— ?
Euomphalus ——— ?

And a few feet below them—

Spirifer ——— ?
Prœtus ——— ?
Streptorynchus ——— ?

In layer No. 4, 60 feet below No. 3 and 150 feet below the station, are the following:

Productus ——— ?
Streptorynchus ——— ?
Ptylodyctia ——— ?

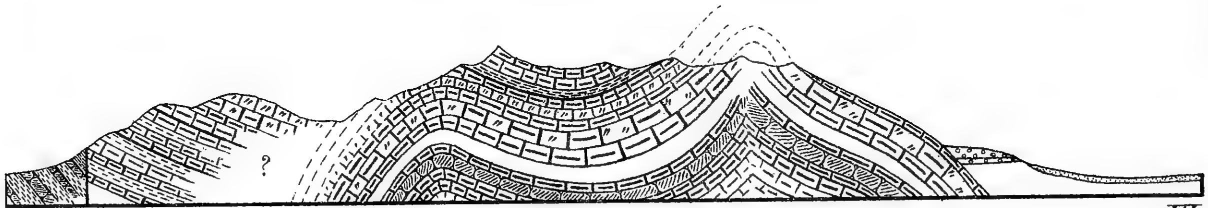


Diagram Showing Structure of the
Salt River Range, on Glacier Creek.

F.D.O.

These prove the Carboniferous age of these limestones, and it is probable that they represent the Coal-Measures. They are higher than the beds of Virginia Peak and below the beds in which fossils were found on the ridge north of Station 56. So much has the range been folded and eroded that the more definite place of the beds cannot be determined with the limited data at our command.

Station 58 is located about 13 miles south of Glacier Creek. The range here appears to be somewhat broader, and instead of two anticlinals, we have here three. The section through the station is represented in an accompanying figure. On the station is an outcrop of quartzite, which, as we trace it north, is seen to dip west, instead of east, as on the station and as shown in the figure.

Five miles north of the station, therefore, the broad synclinal noted on Glacier Creek is still preserved. It is occupied by red sandstones that lie above the shaly and laminated sandstones and limestones of Station 56. The beds on the east side of the synclinal have a dip of about 65° and the west side 45° to 50°. The western anticlinal is here marked by high peaks, the line of the peaks being formed principally by the eastern members of the fold. The axis, therefore, lies to the westward of the peaks, and, as seen from Station 58, the western side appeared to be very steep, the beds having an inclination of 70°, and those on the west an angle of only 25°. Following this fold southward, we find that opposite the point where the secondary anticlinal branches off, there is considerable crushing of the beds. The eastern side of the fold is made up of the limestones below the quartzite of Station 58. They have dips of 78° and 85°, and appear to be crushed against the beds on the western side, which dip west 45°.

Following it south still farther we see it becoming more gentle and perfectly preserved, the axes east of the station being marked by several round-topped peaks. On the south side of Red Creek it is marked by two high and prominent peaks. The dip of the beds is only 25°, but, in addition to the limestones north of Red Creek, the overlying shales and sands and red sandstones are present. The fold becomes much less abrupt and probably disappears west of Mount Wagner. It has been persistent all along the west side of the range, but at Mount Wagner the secondary fold of Station 58 appears to have become the principal one, and forms the west side of the range. Taking up this fold, we find it branching from the principal fold about four miles north of the station. The limestones and quartzites which a little farther north form the eastern side of the main western anticlinal, dipping 50° to eastward, gradually become vertical, and even turn until they dip westward. The principal bed, by the curving or overturning of which this fold could be traced, was the quartzitic of the station. Two and a half miles north it dipped west 55°, and the limestones that in the broad synclinal north form the centre now stand on end. This, therefore, as is evident from the sections, cannot be a true fold, but an upturning of the beds, and the valley west of the station must mark the line of a fault, and the quartzite of the station is really a lower bed than the limestone which lies below it.

Following south of Red Creek, we have seen that the anticlinal to the west has broadened, and that between the line of faulting and the anticlinal there is a broad synclinal. As we approach the eastern side of the synclinal the beds become steeper and steeper (increasing from an almost horizontal position to 40°), and the faulting is gradually becoming a well-defined anticlinal fold. The beds appear to have regained their natural position four miles south of the station. At Mount Wagner the

fold, as seen from a distance, appears complete, and the red sandstones are the only beds on the mountain that are broken through. On the east side the Carboniferous limestones appear to curve over uninterruptedly, the curve being abrupt on the east side. As far as seen, no Jurassic strata are involved in the folds of the range. The direction of the fault fold just described is a few degrees east of south. The fold continues southward beyond the head of Smith's Fork, where it will be again considered farther on in this report.

As we have already observed, the synclinal fold of Glacier Creek continues southward, and its influence is seen in the course of Shoshone Creek at its head. It flows northward along the western side of the ridge, extending south from Station 56. South of Shoshone Creek the depression is filled mainly with the red Triassic (?) sandstones. East of Station 58 the depression is narrow and the eastern side very steep. South the valley widens somewhat, but narrows again near Mount Wagner, and probably disappears south of that point. The anticlinal east of this depression was not crossed, but it is probably very sharp and much eroded. Looking at the range from the Wyoming Range, a bluffy face is presented, back of which sharp peaks rise. These are the summits that mark the anticlinal crest. The following general section was made at Station 58, and corresponds with the figures in an accompanying plate, the letters identifying the beds:

Section No. 15.

1. Massive limestone	a.
2. Gray shaly sandstones and limestones. These are in all probability the beds that outcrop on Station 56, and contain the fossils given in the section (No. 13) of those beds	
3. Red sandstones and shales, probably Triassic	b.
4. Same as No. 3, only reversed in dip	
5. Same as No. 2, reversed in dip	c.
6. Massive limestones. The portion nearest No. 5 being the same as those of layer No. 1. They stand almost on end in the centre, but dip westward as they are followed toward the station, showing an overturn	d.
7. Quartzites	e.
8. Massive blue limestones	f.
9. Yellow and gray shales and limestones	g.

The following section was made from a point west of Station 58 to the valley of Salt River. Beginning at the west, we have:

Section No. 16.

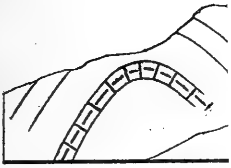
1. Limestones.
2. Shales.
3. Red sandstones.
4. Quartzite.
5. Blue limestone.
6. Sandstones.
7. Blue limestone.
8. Sandstones.
9. Red sandstones.
10. Limestone shales.
11. Blue limestones, in which a *Productus* was found.

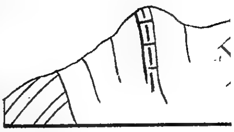
These beds all dip westward at high angles, and against them abut beds of which the following is a general section, beginning at the top:

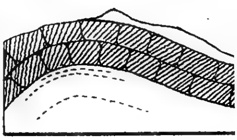
Section No. 17.

1. Blue limestone.
2. Red sandstone.
3. Blue limestone.
4. Greenish and gray limestone.

U.S.Geological S



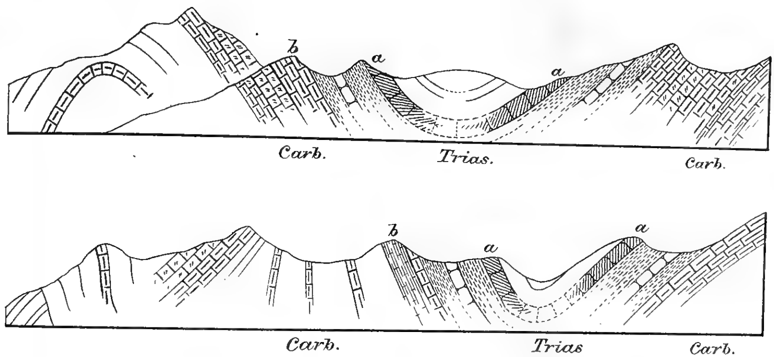




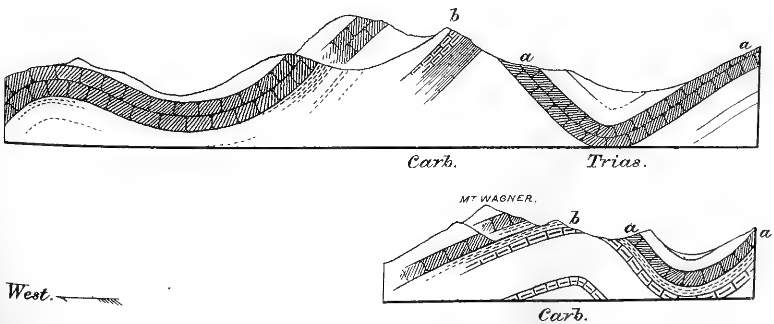
West.

Sections

F.D.O.



Sections North of Station 58.



Sections South of Station 58.

Sections Showing Structure of Salt River Range.

F.D.Q.

The thickness of the beds in the first of the two sections just given is about 4,000 feet, taking the average angle of dip at 50°. In the second section we have about 1,000 feet.

The heights of the peaks in the Salt River Range are from 9,325 feet to 10,988 feet. The greater portion of its drainage is towards Salt River, very few of the streams on the east side cutting into the head of the mountains, as the western streams do.

SALT RIVER.

This is one of the important southern branches of Snake River. It enters the latter a few miles north of our district. Its extreme sources are opposite those of the Western fork of Smith's Fork of the Bear, south of Mount Wagner.

Its valley is divided into two portions by a broad plateau-like mass of hills that branch from the Salt River Mountains. Through these hills the river flows in a low cañon.

The entire length of the valley in our district is about 38 or 40 miles and the average width about 5 miles. The soil is coarse and gravelly, especially in the lower valley. It is covered with abundant grass of excellent quality. The upper valley is about 22 miles in length and about 3 miles in width. The course of Salt River before it enters this valley is west of south. Rising east of Mount Wagner it flows parallel to the waters of Smith's Fork for about 7 miles, when it turns abruptly, making an angle of 40°, and flows west of north. At the mouth of Wagner Creek it turns more to the north and keeps a nearly uniform course to the mouth of Smoking Creek, which comes in from the west, just above the cañon already referred to. This upper valley appears to be located by an anticlinal from which the beds have been mostly removed. We find indications of this anticlinal at the head of the cañon on its east side, and along the east side of the valley the same gray sandstones and limestones are seen dipping in towards the mountains, as noted in the section given on page 550.

What these beds are I was unable to determine, and in Mr. St. John's district they occurred with a great thickness, and he was unable to positively identify them. They resemble the beds noted to the southward on Smith's Fork, and the strikes prolonged evidently fall on the same strata. In the latter region I obtained Laramie fossils from the central beds, and I think the whole series below the Laramie to the Jurassic is present on the east side in that locality. These beds will be discussed again under the head of Smith's Fork.

The Lander cut-off road comes down the Upper Salt River Valley and crosses to Smoking Creek before it reaches the cañon. This portion of the road is used very little. The cañon on Salt River is six or seven miles long and about 1,000 feet deep. Shoshone Creek joins Salt River about the middle of the cañon. The lower valley of Salt River continues northward from the cañon until it is merged in the valley of Snake River, which has the same direction. The valley in this lower portion is terraced. Between Glacier and Strawberry Creeks the soil is gravelly, and the surface strewn with limestone pebbles and bowlders. Although this portion of the valley is unfitted for agricultural purposes it is covered with good grass. The valley is about six miles wide at the widest part, and the elevation is about 6,000 feet. The river is crowded to the west side, close to the rolling hills that separate Salt River from the branches of the Blackfoot. In this lower valley, on the east side, a conglomerate shows at the edge of the mountains at several points.

The beds that dip eastward against the limestones at the mouth of Red Creek, appear to have been eroded here, and this conglomerate deposited on the top of it. This conglomerate is horizontal and shows also on a butte between Glacier Creek and Salt River. It is made up of pebbles of limestone of all sizes and shapes. The plateau-like mass, extending west from the Salt River Mountains north of Glacier Creek, appears to have been the northern limit of the lake in which the conglomerate was deposited, as no remnants were seen in the upper valley.

The strike of the beds in the plateau of the cañon appears to be a few degrees west of north. At the head of the cañon the river is a little west of the anticlinal axis which, I think, crosses the river some distance below. The river from here has a direct northern course to its mouth. The influence of the strike of the beds in these hills is seen in the creeks in the upper valley coming in on the east side. These are Wagner Creek and Red Creek.

Wagner Creek is formed by two branches, which join near the mouth. The southern branch is the largest. It drains the country north and west of Mount Wagner. Its extreme sources are in the very centre of the range, the geology of which has already been given. The northern branch heads on the western slopes of the mountains. As these creeks emerge from the foot-hills they are flowing about due west, but they soon turn and flow northwest.

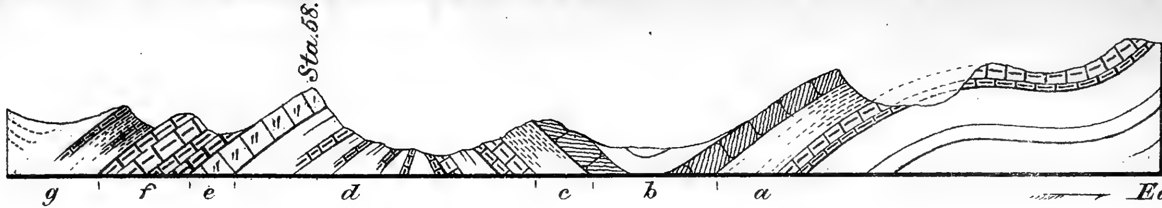
Red Creek is a few miles north of Wagner Creek. Its sources are in the red beds of the synclinal depression east of Station 58. Collecting water from north and south it flows slightly south of west in deep cañon for six or seven miles. Immediately on leaving the foot-hills it turns to the northward and flows northward and westward to its mouth, which is between the mouths of Clear Creek and Crow Creek. In this portion of the valley there is considerable swamp and marsh, and the underlying beds are covered with drift.

Clear Creek rises east and north of Station 58, in a rugged portion of the range. It cuts its way out in a deep and almost inaccessible cañon. Its course in the valley is straighter than that of Red Creek, and more nearly westward.

Traces of old beds for these creeks can be seen in the valley.

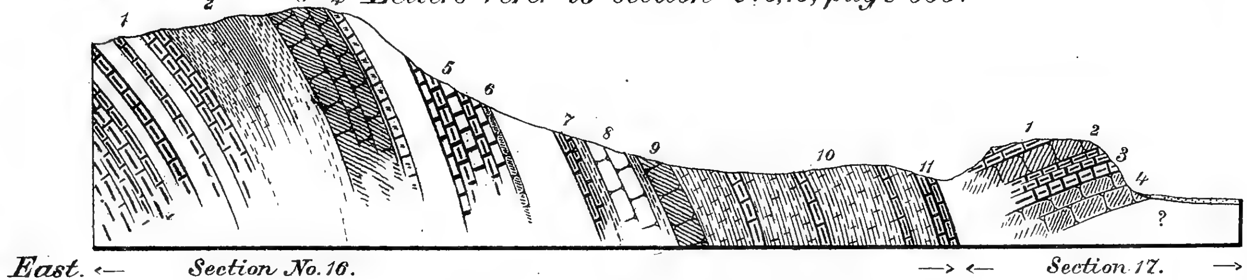
Shoshone Creek, as we have already noted, cuts through the plateau. Its head is approximately parallel to that of Glacier Creek. The stream was not followed but simply crossed near the mouth, where its course is about due west. Nearly all these streams have fringes of willows and a few cottonwoods on their banks.

Glacier Creek.—This creek was named from the two glacier-like masses noted on two of its sources. These have already been described. This creek is the one the Indian trail from John Day's River follows to the valley of Salt River. The cañon is very rough, and the trail rather difficult. We were obliged to cut out the brush at several places. It is also very rocky, especially below the point where the creek turns to the eastward. Its head is on the line of the anticlinal that marks the eastern crest of the Salt River Range. Following this line on the line of a probable fault, for about four miles, the creek turns to westward across the abrupt anticlinal already described. It is here that the cañon is roughest, and the creek descends most rapidly. From this point it crosses a broad synclinal of Carboniferous limestones, from the centre of which very little has been eroded. Finally, the anticlinal forming the west side of the range is crossed, and outside abutting against these limestones is the Salt River Conglomerate as I have named it. The trail crosses over this on the north side of the creek. The change from the



Sections through Station 58.

Letters refer to section No, 15, page 550.



Section West of Station 58, to Salt River Valley.

Figures refer to Sections Nos, 16 & 17, page 550.

Sections in the Salt River Range.

F.D.O.

snowbanks at the head of the creek, and the gloom of the cañon, to the grassy valley, broad and sunny, was a startling one. In the valley there is a straggling growth of cottonwoods along the creek, the spaces being filled with willows and other brush. The creek flows rapidly, and its bed is very rocky, without any bordering grassy meadows.

Between Glacier Creek and Strawberry Creek the valley is broad and level.

Strawberry Creek rises south of Station 57, and is the only creek that reaches Salt River in this part of the valley. A number of creeks come out from the mountains but sink before they reach the river. From the hills a number of old creek-beds can be distinctly traced by the line of cottonwoods, most of which are dead, the withdrawal of the water having killed them. On the west side of this lower valley of Salt River a large number of small streams come from the hills to the westward, but none of them were visited. The strata composing the hills are evidently the same as those outcropping farther south on Crow Creek and Beaver Creek, but the area between Smoking Creek and Salt River was not traversed by us, so that nothing definite can be said regarding its geological features. Mr. St. John made a section across a portion of the region north of this, and this section indicates the rocks to be similar to those noted in Salt River Cañon at the lower end of the upper valley.

In the upper valley there are two large creeks joining Salt River from the west, viz, Crow Creek and Smoking Creek. Crow Creek is joined a few miles above its mouth by Beaver Creek.

Beaver Creek.—Beaver Creek rises in the low, rounded hills east of the head of Crow Creek and north of the divide between Crow Creek and the branches of Thomas's Fork of Bear River. At the head there is a marshy valley with a north and south direction. The stream here flows a little east of south. This valley marks an anticlinal. The few outcrops that can be seen in the hills on the west side of this valley indicate a western dip, while on the east side the rocks are dipping east in a ridge extending northwest and southeast. East of this is a second ridge with dips in the same direction. The beds are coarse conglomerates, sandstone and limestone pebbles being included. On a third ridge a location was made on a coarse conglomerate containing pebbles of limestone, quartzite, and red sandstone of all sizes and shapes. The beds are pink and reddish in color and are probably the northern continuation of similar beds seen on Thomas's Fork north of Station 41.

The station just referred to is near the line of a synclinal axis, for on a station just north and a little east we have the conglomerates dipping west; and east of Beaver Creek here is probably an anticlinal in the gray sandstones. At the second location just mentioned we have the following beds, showing:

Section No. 17½.

1. Gray sandstones outcropping on both sides of Beaver Creek.
2. Greenish-gray sandstones forming a hogback-like ridge.
3. Reddish sandstones and conglomerates.
4. Coarse conglomerates of the location.

South of these two locations, Beaver Creek flows towards the east until gradually it begins to turn northward, and flows northward in a monoclinal of gray sandstones. It finally cuts across an anticlinal to its mouth. This anticlinal is probably the anticlinal of station 41 with the beds of the station removed. The divide south of the locations was so high that they could not be traced between the points. Putting

down both strikes on the map, it seems probable that they connect the two localites.

Crow Creek.—Crow Creek rises opposite the head of Preuss Creek. It receives its water mainly from the eastern side of the Preuss Range. In this portion of its course the creek flows northward. The range on the west is composed of Carboniferous limestones in almost vertical position, dipping about 80° or 85° to the eastward. On the east side of the creek occur the beds that have been noted on Beaver Creek. The relation between them and the limestones of the range could not be determined. I think that between Beaver Creek and Crow Creek there is a synclinal and perhaps an anticlinal. On receiving a large branch from the Preuss Range, Crow Creek turns eastward, and soon crosses the anticlinal of the head of Beaver Creek. A few miles below, two creeks come in nearly opposite each other. The one from the south occupies the synclinal noted at the two locations made in the bend of Beaver Creek. Between this point and the valley of Salt River there are two anticlinals and a broad synclinal. The eastern anticlinal forms a rounded hill facing Salt River Valley. It is composed of greenish-gray sandstones. The section from this hill to the beds of the central portion of the anticlinal is the following:

Section No. 18.

1. Greenish-gray sandstones with bands of shale.
2. Purplish and reddish sandstones.
3. Conglomerates.
4. Red sandstones.
5. Gray shales.

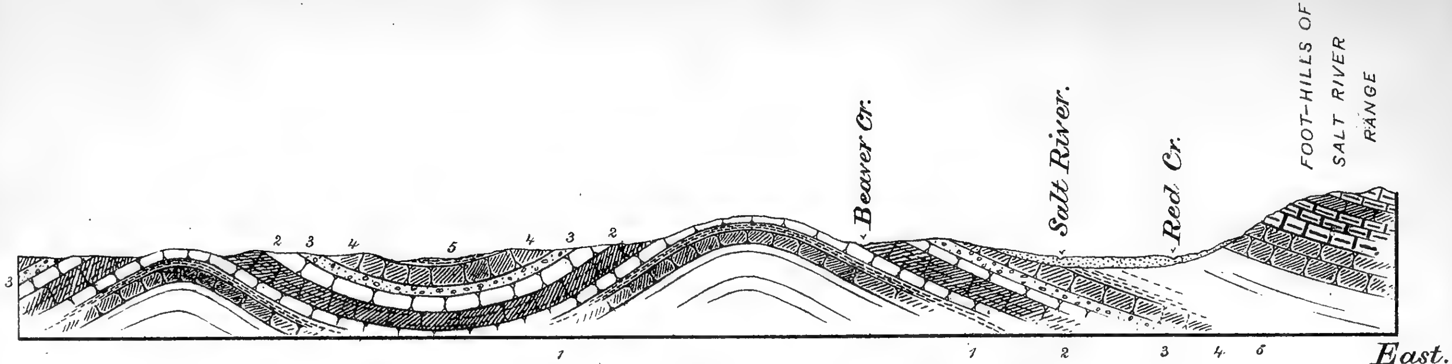
The red sandstones, No. 4, and conglomerates, No. 3, are probably the same as noted on Beaver Creek.

On the north branch of Crow Creek the conglomerates dip eastward on the east side. On this creek, near the main stream, there are remnants of old spring deposits forming dams of calcareous tufa across the creek. The beds on the west side dip west. On a station at the south end of the ridge, Mr. Mushback observed limestones, probably Carboniferous; and on a station north of this, but probably east of the axis line of the ridge, Mr. Gannett noted sandstones, but of what age I could not determine.

The valley on this branch of Crow Creek is broad and well grassed. A number of small branches come in from the west.

Smoking Creek.—This is the only large branch of Salt River not yet described. It drains the country north of Crow Creek, and consists of two principal branches, one coming from the north having its sources opposite those of the Blackfoot River, and the second coming from the south through a broad valley similar to the one on the branch of Crow Creek last described. When these two streams unite the direction is changed to east, and the stream formed forces its way to Salt River through a cañon cut in low rolling hills. It is in this region that the salt beds occur, from which Salt River derives its name. On the west side of Salt River, below the mouth of Smoking Fork, there are salt flats, and where the two branches of the latter stream unite above the cañon there are numerous salt springs. Here is where the old salt works were located, at the point where the old Lander road crosses the creek.

In the bluff east of this place red and gray sandstones are seen dipping eastward. The reddish beds are below, and seem to be the ones from which the salt is derived. Farther east an anticlinal fold was seen. This region was not thoroughly explored, as time did not permit our going through these hills. The evident structure, however, is a series



Figures refer to Section No, 18. page 554.

Section along Crow Creek
to East Side of Salt River Range.

FDO

of gentle folds in the gray and reddish sandstones and conglomerates noted farther south. North of our district the beds occur also, and were doubtfully referred to the Cretaceous by Mr. St. John. We did not find any fossils in them, and cannot, therefore, refer them positively to that age in our district. The salt works are situated on the North Branch a mile or two above the junction of the streams. The company is termed the Oneida Salt Works Company, operated by B. F. White, of Malade City, Idaho.

The following information was obtained from Mr. G. W. Gordon, who was in charge when we passed the works: There are several springs, but only one was being used. No pumping is required, but the water is run through wooden troughs into three vats. Two hundred thousand pounds per month was the yield, at an expense of about $20 per day. The force working was ten men, a portion being employed in cutting wood in the adjacent hills. This force would be reduced to five men after the wood was cut. At the works the salt was sold for 1¼ cents per pound. When delivered by the company the price, of course, is dependent on the distance from the springs and the mode of sacking. The principal market for the salt was Idaho and Montana, large quantities being sent to the mining regions. The wagon road (Lander's cut-off) passes the works and follows up the creek from which it crosses to the head of the main Blackfoot.

At the head of Smoking Creek we made two stations (Nos. 63 and 64). On Station 63 gray sandstones outcrop, dipping steeply to the eastward or northeastward, and a short distance south on the ridge they dip steeply to the west. Above them are red sandstones, also dipping west or southwest. On Station 64 the dip is west, so at Station 63 there is evidently an overturn. Below the stations is a steep bluff, facing the northeast. Reddish beds outcrop at the foot of the bluff, and there appear to be salt springs along its edge. Between the stations and the wagon road are shaly limestones, dipping southwest. Above them are coarse conglomeratic sandstones. These beds have the appearance of Jurassic strata, but no fossils were found to prove it. Following down the ridge from Station 64 the strike appears to curve to westward and southward. On Station 67, which is between the Blackfoot and the head of Smoking Creek, there is a dip to the northeast, so between Stations 63 and 64 and Station 67 there must be a synclinal. On the latter, the beds, as seen from a distance, and from descriptions given by those who were on the station, must be the Triassic red sandstones. There has been some crushing and folding in this region, but we could not spare the time to investigate it. Farther south on the ridge the dip in the sandstones (at Station 62) is also toward the east, but the inclination appears to be more gentle than it is to the northward. The range, therefore, is a monoclinal as we view it from the west, but toward the east there is a broad synclinal. The strike of the beds appears to curve from east of south to south and west of south as we follow the ridge southward toward Crow Creek.

These folds will be referred to again when describing the Blackfoot, as they are developed between the branches of that stream which head in the spurs of the Preuss Mountains.

We have therefore seen that the country between the Salt River Range and the Blackfoot is filled with gently-folded rocks, forming comparatively low, rounded hills. The rocks, especially those west of Salt River, seem to indicate deposition in rather shallow seas. A fault appears to extend along the western side of the Salt River Range, while the relations between the faulted beds and the Preuss Range are not

apparent. Toward the north there is considerable complication. The cause of some of this complication is, perhaps, to be found in Mr. St. John's district in the uplift of Caribou Mountain.

After the elevation and folding of the beds, a lake filled the lower valley of Salt River. Since the draining of this lake its deposits have nearly all been removed. As to its age, we have no certain clue. The probability is that it was Post Pliocene.

As to the age of the conglomerates, red sandstones, and gray and greenish shales which enter into the structure of the hills on Crow, Beaver, and Smoking Creeks, we are in doubt; but the probability is that they represent the Cretaceous and Post Cretaceous. Near Station 41 Laramie fossils were obtained; and Mr. St. John obtained a leaf of Cretaceous facies farther north from the similar beds.

BLACKFOOT BASIN.

Blackfoot River is a large stream with a most eccentric course. The main stream heads opposite the heads of Smoking Creek. Curving around the dividing ridge which separates them, it flows south into the northern portion of the valley of the East Fork of the Blackfoot. When the latter stream joins it, it turns abruptly and forces its way in a cañon across the ridge that forms the western boundary of the valley, flowing southwest until the South Fork comes in, when it turns to the northwest, keeping that course until it is joined by a branch from the north, when it flows westward into the broad plain-like valley which has been called the Hollow Hand. Through this it flows sluggishly with northerly and northwesterly courses to the north line of our district. Here it turns once more, flowing south of west, and finally leaving our district with a northwest course among the spurs of the Blackfoot Range. The most noticeable feature of the Blackfoot region is the basin-like character of the country. Hitherto we have crossed a succession of mountain ranges alternating with broad valleys whose directions are parallel to the axes of the ranges. Now, however, the valleys assume different directions. The only regularity or system is seen in the southern or southeastern branches, which rise in the spurs of the Preuss Range. I shall take up these in order.

East Fork of the Blackfoot.—This creek is, in reality, the head of the river, although its course is at right angles to the course taken below its mouth, while the stream from the north does not make so abrupt an angle.

The direction of the valley is northwest. Viewed from a high point, it is seen to be the same as the direction of the valley of Smoking Creek and that of the South Fork of the Blackfoot. It is about a mile in width in the widest portion of the upper valley. This narrows a little as we go down, but widens again, until in the lower valley it is between two and three miles. Here there is considerable swamp and marshy ground, and the streams are divided, enclosing islands. On the north side of the Blackfoot, near the mouth of the East Fork, there is a table of basalt, which extends down the river as far as the head of the cañon. The valley of the East Fork was not followed, but, as seen from the surrounding ridges and hills, its beds must be concealed. On the east side is the ridge forming the divide on the west of Smoking Creek. Red sandstones, probably Triassic?, outcrop at the top of the somewhat bluffy face fronting East Fork. Carboniferous limestones, probably, outcrop in the lower part of the bluff. The dip of the beds is to the eastward, and the same dip is noted in the ridge on the west, so the

valley is a monoclinal valley. The ridge on the west side is the northern continuation of the Preuss Range. The cañon of the Blackfoot marks a point of curving in the strike. The cañon is cut in the western portion of the ridge, and the limestones through which it is cut dip to the southwest. Following the ridge to the south, the strike is seen curving to the south. A station was made on the ridge nearly opposite the head of the East Fork. Light-colored limestones formed the summit, with underlying quartzites. In the limestones I obtained—

Hemipronites crenistria.
Rhombopora lepidodendroides.
Productus, like *P. costatus.*

These proves their Carboniferous age. The beds dip steeply to the northeast. The hills just east were too high for us to see definitely the geological structure in that direction, and it was storming too hard to allow us to follow the ridge northward from the station. As seen from the valley on the west, the northern portion of the ridge has the strata dipping west. This dip also is seen in the cañon of the Blackfoot, as already noted. Another station (*b*) was made six miles farther south, on coarse, arenaceous limestones, the strike being a few degrees east of north, and the dip a few degrees north of west. Between the two stations (*a* and *b*) there must, therefore, be a curve in the strike.

It is evident, from what was observed, that this ridge is a sharp anticlinal, with a slip in the beds on the west side, as indicated in the accompanying illustration of the section. The western side of the ridge is a bluff face, rising 1,200 feet to 2,000 feet above the valley. It increases in elevation southward. In the southern end of the range the western members of the anticlinal form the principal mass of mountains. On Station 61 the limestones are nearly vertical, dipping a little north and west. Station 60 is a short distance south and west of Station 61, and there the limestones dip steeply to the westward. From the latter station Mr. Gannett brought in an indistinct fragment of a *fenestella?*. South of Station 60 the topographical features indicate that there may be a curving of the beds to the eastward, implying some connection between the Preuss Range and the Sublette Range. The region between the two was, however, not visited, and this opinion is therefore merely conjectural. I have considered the Preuss Range at this place because it has seemed the most natural, as the ridge west of the East Fork of the Blackfoot is its northern continuation. I shall speak of it again when speaking of the drainage of Bear River.

Middle Creek.—This name I have applied to the stream coming into the river between the East Fork and the South Fork. The stream is small and unimportant, but the valley or depression is a large one, and continues southward beyond the head of the creek parallel to the high ridge which rises above its eastern side. The valley is parallel to those of the East and South Forks. Its length is about 14 miles altogether, while Middle Creek has a length of about 6½ miles. In the upper portion of the valley is a creek having approximately the direction of Middle Creek. Seen from any of the surrounding points it appears to be the same stream, but when followed is seen to cut across the western ridge to the South Fork of the Blackfoot.

This upper valley was perfectly dry when we traveled up it about the middle of August. North of it is another creek which rises against the bluffy wall on the east side of the valley and flows directly across the ridge parallel to the creek just described. From this stream a range of low hills extends northwestward to the Blackfoot. This range is a syn-

clinal with the western side most prominent. The valley of Middle Creek is therefore a monoclinal. About two miles south of the most northern of the two creeks that cut through the ridge a station was located. Gray sandstones dipping rather steeply to the northeast formed the summit. Below these, near the base of the hill on the west side, was an outcrop of limestones dipping in the same direction, and containing the following fossils:

Meekoceras aplanatum.
Meekoceras gracilitatis.
Aviculopecten altus.

These prove the beds to be of probable Triassic age. The outcrops are few and somewhat obscure, as the hills are rounded in their outline.

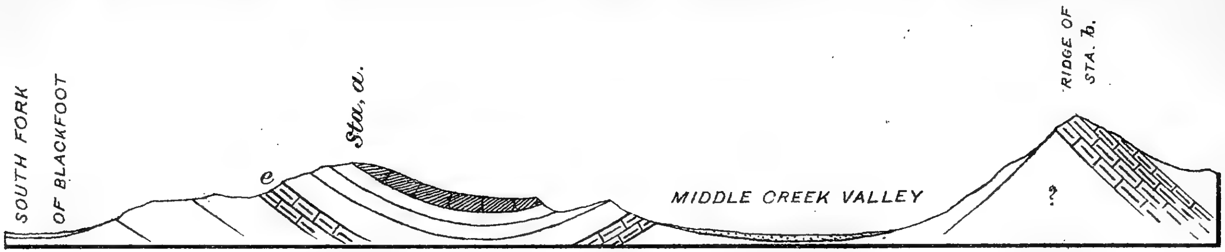
The axis of the synclinal lies to the eastward of the line of the ridge. To the southward the hills disappear and the synclinal cannot be definitely traced. There are traces of a synclinal west of station *b*, which may be the same one, but its relations are obscure.

South Fork of the Blackfoot.—This is probably the most important branch of the river. It is made up of two creeks, one rising in the angle between the Preuss Range and Aspen Ridge, opposite the head of Twin Creek, and the other draining the western slope of Aspen Ridge. The two valleys are in general parallel, and are separated by a spur from Aspen Ridge, which is probably an anticlinal axis. The western branch, about eight miles below its head, turns to the eastward and cuts acros this ridge to join the eastern branch. Directly north from the bend, and continuing the line of the valley, is a small branch of the Blackfoot separated from this stream by a low divide.

The main branch has a length of some 15 miles. For the most part its valley is broad and well grassed. Two of its branches, as we have already noted, come from the eastward through the ridge that bounds the valley on the east. On the west side of the valley below the mouth of the western branch the beds exposed in the bluff dip north of east, and in the divide east of Station 89 the dip is south of west, so between the two points there must be an anticlinal, which is probably the same as that in the hills separating the two branches of the South Fork. The western branch probably occupies the anticlinal axis just before it cuts across to join the eastern branch. The rocks are probably all Jura-Triassic. In the valley of the Blackfoot opposite the mouth of the South Fork there are isolated patches of basalt showing on the north side of the river. I could not determine the presence of basalt on the south side, and it probably does not occur on that side of the river.

Aspen Ridge.—This ridge forms the divide between the South Fork of the Blackfoot and Bear River. It is a spur from the Preuss Range. Its trend at first is about northwest, but as it is followed it turns slightly to the northward. It is about 24 miles in length. The southern end near the Preuss Range is heavily timbered and the geological structure somewhat obscured. There are probably two anticlinal folds between the Preuss Range and the valley of Bear River; the western one is probably considerably eroded.

On Station 90 there are sandstones and limestones outcropping containing *Ostrea strigulecula* and obscure Jurassic forms. These beds are so covered that the dip cannot be determined, but on the hill west of the station it is south of west, or west, and in the cañon leading down from the station to the Sulphur Springs the dip is, in general, west. Near the foot of the cañon, however, we cross limestones with a strike of north 7° east. Before reaching this point the beds are dipping west about 50°.



e = Position of Meekoceras aplanatum &c.

Section through Sta. a.

This increases to 80°, and we cross a synclinal axis, the west side of which dips south of east 50° to 60°. The beds in which these strikes and dips were observed were massive limestones, probably Carboniferous. The strikes continued southward would fall on the hills west of Bear River. It seems probable that a short distance north of this cañon the beginning of a secondary anticlinal might be found.

On Station 89, sandstones and limestones, like those of Station 90, outcrop, and contain similar indistinct fossils. The dip, however, is north 42° east, or at right angles to the trend of the range from this point to the Blackfoot. West of the station it is difficult to determine the dip, but it appears to be toward the southwest. If this be so, the station is almost on the line of an anticlinal fold, and Station 90 is also probably on the same line. East of Station 89 a westward dip was noted.

South of Station 90 the ridge presents a somewhat bluff face toward the valley of the South Fork of the Blackfoot, and the dip is probably to the southwest, but of this I cannot be certain, although the bluff face would seem to indicate it. At the northern end of the ridge Mr. Gannett found a capping of basalt 500 or 600 feet above the level of the valley. Limestones outcropped beneath the basalt.

Reviewing this region of the southern branches of the Blackfoot, we find it to consist topographically of four wide valleys and four ridges or spurs from the Preuss Range. The crests of the most eastern and the most western are separated by an interval of about eleven miles. The ridge on the west is 8,448 feet high in the highest part, and that on the east 8,879 feet. The two ridges between are low and present rounded outlines, and the valleys are broad and well grassed.

Geologically we find a series of anticlinal and synclinal folds. The streams sometimes occupy the axes of the folds, and sometimes are in monoclinals. There are at least three anticlinal axes that are parallel, having the general direction northwest and southeast. These are separated by corresponding synclinals. In the eastern anticlinal there is a slip in the beds, as shown in the accompanying plate, which gives a better idea of the structure of this region than can, perhaps, be given in words.

Another thing that is noticed is the gradual curving in the strata. Strikes which farther south are approximately north and south now curve to the westward, until by the time our north line is reached the strike is northwest and southeast. The cause of this change may, perhaps, be looked for in the uplift of the Teton Range in Mr. St. John's district.

With exception of the northern end of the Preuss Range, the rocks are mainly those of the Jura-Trias, as determined by the few and indistinct specimens secured. On the west side of Aspen Ridge a limited outcrop of Carboniferous appears, the massive limestones occurring there having been so referred on lithological grounds.

Toward the south the low rolling ridges culminate in the rugged peaks of the Preuss Range, much narrower, but attaining a greater height. Northward we find them dying out, and forming isolated hills and short ranges in a basin-like region, the lower places being filled with basaltic flows and drift deposits.

This region would form a most excellent summer range for cattle. It is a little high for general agricultural purposes.

Northern branches of the Blackfoot.—There are two good-sized creeks having their origin in the hills south of John Gray's Lake. The most eastern of these has a southeasterly course. It heads in rocks of Jura-

Triassic age, south of Station 66 and its entire course is probably in rocks of the same age. Near its mouth red sandstones outcrop, dipping at right angles to the course of the river; *i. e.*, to the northeast. North of this stream two small and unimportant creeks flow into the Blackfoot. West of it there are two more, one joining above the cañon and the other below. Then we reach the stream that comes from Station 65 and flows southwardly into the Blackfoot, joining it opposite the northern end of Aspen Ridge. The region between these two principal creeks is eroded into ridges composed of Jura-Triassic and Carboniferous rocks, the continuation of those between the southern branches of the river. Only two stations were made in this region, viz, Nos. 65 and 66. They were located on the ridge south of John Gray's Lake. Station 65 is near the north end of the ridge on limestones with a strike of south 33° east, dipping at an angle of 55°. The strike curves to the eastward at the southern end of the ridge, making an acute angle with the trend. Above the limestones there are quartzites, and above the latter very dark blue limestones. The lower limestones are probably the upper part of the Carboniferous. In them at several places I noted the occurrence of oval concretion-like masses arranged in concentric rings. I am inclined to regard them as fossil remains rather than concretions, as I noticed a number of them branching. They appear to cross the lines of stratification.

The following general section was made in which the thicknesses are only estimated:

Section No. 19.

Base.	Feet.
1. Massive limestones outcropping on Station 65. Could not trace the beds below angle of dip 55°	400+
2. White quartzite 3. Dark blue limestone	800
4 Reddish and greenish laminated sandstones	400
5. Bluish-gray limestones	700
6. Greenish and reddish sandstones and limestone shales alternating	850
7. Limestones outcropping on Station 66 8. Alternating limestones and shales outcropping in ridge running south from Station 66	1,000+
Total	4,150+

In stratum No. 5 the following fossils were obtained:

Meekoceras gracilitatis*, White.
Meekoceras mushbachanus, White.
Arcestes? cirratus, White.
Arcestes, two species.
Eumicrotis curta, Hall.

In No. 6 three or four undetermined *conchifers* and a new species of *Aviculopecten* were found.

In No. 7 the following:

Eumicrotis curta, Hall.
Aviculopecten idahoensis, Meek.

And in No. 8, near the top:

Terebratula semisimplex, White.
Terebratula augusta, Hall.
Aviculopecten idahoensis, Meek.
Gervillia and undetermined *conchifers*.

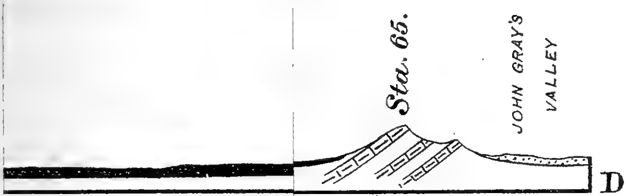
The discussion of the age of these beds is left to a future chapter.

The ridge presents the appearance of a monoclinal as do all the iso-

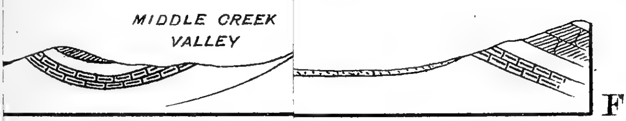
* The genus *Meekoceras* is a new one established by Prof. A. Hyatt. (See Bulletin U. S. Geol. Survey, vol. v, No. 1, 1879, p. 111.)

Plate LXII.

ction lines AB Map in Plate LXIV.

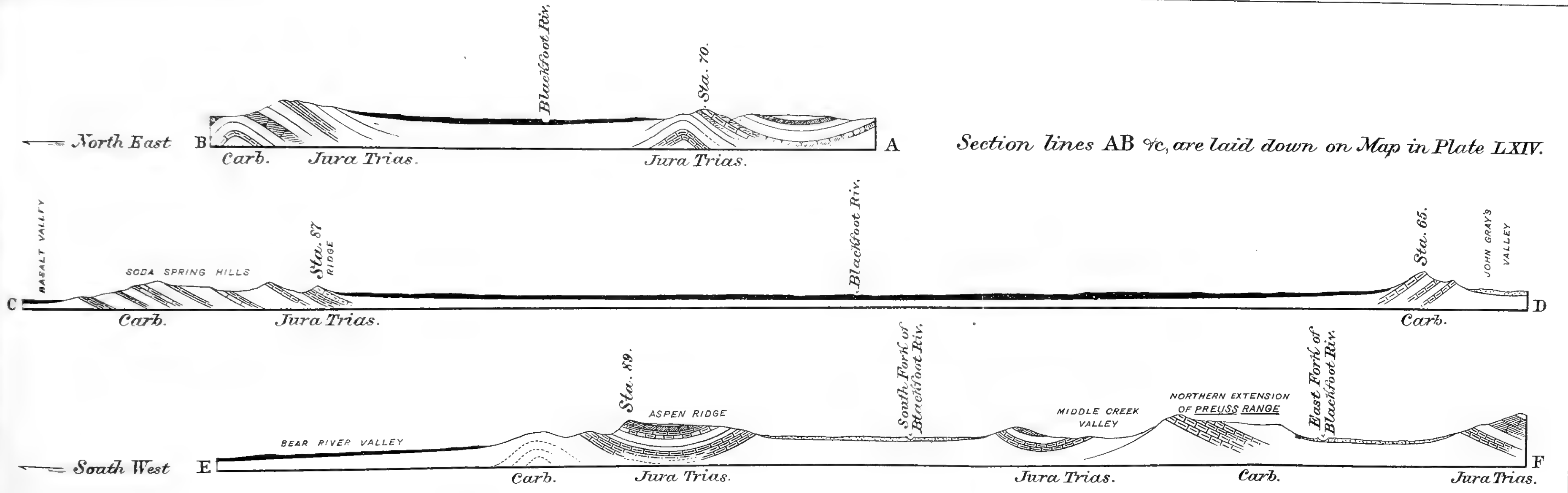


Carb.



Jura Trias. *Jura Trias.*

n.



Sections in the Blackfoot Basin.

F.D. Owen. del.

lated ridges in this region. In the low hills east of the head of the creek draining into John Gray's Lake, dips to the west and northwest are seen, with what appears to be a curving in the strata towards the south and west, as if it were connected with the curving noted on the ridge of Station 66. There is here, therefore, evidently the southern end of an anticlinal. Only a small portion of the eastern side is apparent here. It consists of Jura-Trias sandstones in which occur a number of indistinct fossils, among which a *Tancredia* was all that could be identified. The western members of the anticlinal therefore form the ridge. Northwest of this ridge on the west side of the lake, in Mr. St. John's district, is another isolated ridge. In this the eastern members form the ridge. Between the two ridges there is probably a slight curving in the axis. West of this ridge is another, seen by us only from Stations 65 and 66. It is broader but appears to show the same monoclinal structure, although it is in reality the western side of another anticlinal. Northwest of this is another isolated ridge in Mr. St. John's district, composed mainly of Carboniferous beds, a small area of Jura-Trias showing on the east side. On the west side of the Blackfoot is still another of these isolated mountain ridges on which Station 70 was located. This will be referred to again further on. There can be no doubt that these beds are the same that are exposed south of the Blackfoot, and that these isolated hills and ridges are the eroded remnants of the anticlinals that form the ridges between the southern branches of the Blackfoot. The surrounding valleys are filled with basalt which extends up on the flanks of the ridges. This basalt occupies also the valley of John Gray's Lake. The region southeast of John Gray's Lake is occupied by rocks of Cretaceous? and Jurassic age. There is considerable complication in the region just northeast, which made it difficult to determine the age and relations of these beds in the hurried examination we were obliged to make. Mr. St. John's report on the region immediately north will throw considerable light on the structure of this region, as the cause of the disturbance lies within his district.

West side of Blackfoot River.—When the Blackfoot emerges from the ridges and comes out into the broad open valley, or "Hollow Hand," as it has been called, it flows in sluggish course through broad meadows and marshes. On both sides are seen the edges of the basaltic plain that forms the "Hollow Hand." On the east side of the Blackfoot the flow appears to have come mainly from a point about five miles back of the river. Here two crater-like hills were seen. Near the north line of the district another crater was observed.

Southwest of the Blackfoot there are at least two craters. On one of these a station was located. It is circular and rises about 500 feet above the surrounding surface. On the summit is a circular concavity 130 yards in diameter. It is from 10 to 20 feet deep, and the rim is about 50 feet in width and made up of black, red, and yellow scoriaceous basalt. Basalt surrounds the cone, and on the east side seems to have an inclination away from the cone in a succession of layers. On the west this is not noticed, as the other cone is only a little more than two miles distant. The latter is not so regular, its sides appearing to be much broken down.

About four miles southeast of these two cones a station was made on a high butte which, judging from the specimens brought in by Mr. Mushback, is either a crater or the remnant of one. The scoriaceous rocks from the summit were all light colored, having a glassy appearance under low-power glasses.

Scoriaceous rock is found on the basalts at several places, and a vol-

canic ash occurs with it on the Blackfoot. Between the buttes north of the station is a circular depression occupied by a lake. It also has the appearance of an old crater.

The Great Basalt Plain extends westward to the east base of the Soda Springs Hills, and a flow of basalt passes through a depression in them to Basalt Valley, where it forms the plain between the Upper Portneuf Valley and Gentile Valley, on Bear River. The gap through which the basalt poured is southwest of the craters. It is cut through Carboniferous limestones and is only about a mile in width. Southward the flow extended *via* Soda Springs Valley into the valley of Bear River, connecting along that stream with the Basalt Valley flow.

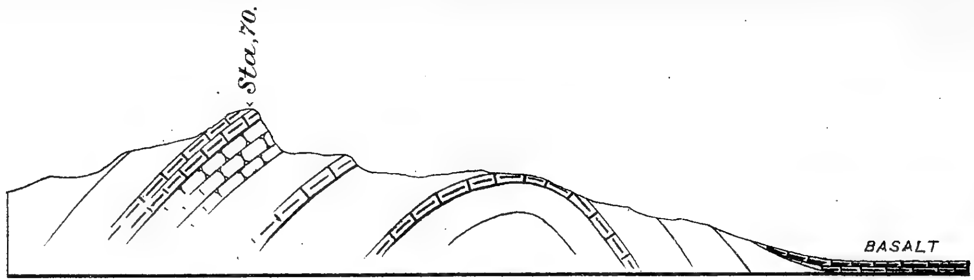
There is no drainage outlined on the basalt in the basin of the Blackfoot. All the streams in this region sink beneath the crust. A few streams are seen to begin on the basalt, but they can be traced only a short distance, when they disappear. There have probably been several outpourings of basalt, but our limited time did not permit us to follow the succession of the rocks sufficiently to determine them.

North or a little west of north from the volcanic craters is a group of hills occupying an area of about 18 square miles. On the highest point of this group Station 70 was located on an outcrop of limestone, beneath which were sandstones similar to those of Stations 89 and 90. The outcrops were obscure, but the dip appeared to be to the west or southwest. The angle could not be determined. On the ridge leading down northward from the station, a dip in the opposite direction was noted. These hills are, therefore, a remnant of an anticlinal axis, the western members of which form the major part of the elevation. On the Blackfoot, about five miles northwest of Station 70, the northeastern dip is seen again in the cañon wall, a point of the sedimentaries rising above the basalt, limestones and shales outcropping. On the north side of the river this anticlinal rises into a high ridge that continues northwestward into Mr. St. John's district. The line of the strike of the beds here and those of Station 70, when prolonged, falls on Aspen Ridge. There is therefore every probability that it is the same fold. Basalt covers the country surrounding the hills of Station 70. It is generally destitute of timber. Sometimes a few aspens and low brush are seen on some of the creeks. The limestones on Station 70 contain numerous specimens of *Terebratula augusta*. The sandstones below are filled with an *Aviculopecten*, among which, probably, two new species exist. The beds are all undoubtedly of *Jurassic* or *Triassic* age.

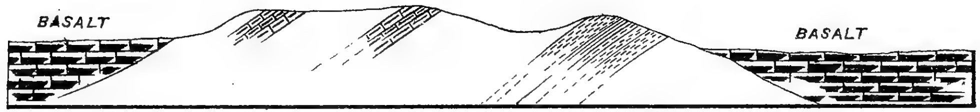
Lander's road crosses the Blackfoot almost on our north line. The river here is broad and very sluggish and full of vegetation. The crossings are few and generally muddy. Below the crossing of the road the river turns abruptly and flows southwest into a cañon, the walls of which are principally basalt. On the south, as I have already noted, limestones and shales outcrop at one locality. The basalt is horizontal, and appears to follow the cañon of the river a long way to the northward.

In the cañon, a short distance below the outcrop of limestones, there are calcareous spring deposits. Only one active spring was noted, with very little water escaping. The temperature at 7 a. m. was 82° F., the air being at 55° F. On tasting the water the presence of carbonic acid gas and iron was recognized. The deposits were calcareous as far as seen.

Between the head of the Portneuf and the Blackfoot, outcrops of light-colored sandstones and conglomerates were noted, appearing to occupy a basin which extends northward into Mr. St. John's district, and which



Section through Sta. 70.



Section on South Side of Blackfoot River North of Sta. 70.

F.D.O.

will be more fully described by him in his report. Mr. St. John considers them to be of the same age as the lake beds exposed on Bear River which contain similar fresh-water forms.

PORTNEUF RIVER.

The Portneuf is a large branch of the Snake, and has a rather curious course before it reaches that river. It rises north of our district and flows south for about fifteen miles from its head into the broad upper valley. It then turns southwest across the valley and gradually enters the cañon. In the latter it soon takes a southern course again, which it keeps for about ten miles, when it makes a right angle and flows westward across the range, and after a course of almost ten miles in that direction makes another right-angled turn out into the valley of Marsh Creek, in which it flows northward, separated from Marsh Creek by a narrow strip of basalt. At the north end of this valley it again turns to the west to cross Bannock Range, after which it leaves our district with a northwest course to flow out into the Snake River Plains.

Upper Portneuf Valley.—The upper portion of the Portneuf is in a broad grassy valley, which is the northern extension of Basalt Valley, which reaches to Bear River west of the Soda Springs Hills. Opposite the point where the Portneuf enters the cañon the valley is about eleven miles in width. The hills on the east side are mainly Carboniferous, especially at the south end of the valley. Jurassic rocks may outcrop toward the north, but they were not recognized. On Station 82 limestones outcrop, dipping northeast, and containing

Productus Costatus,
Spirifer Rockymontanus,
Crinoidal stems.

In 1871 the following fossils were obtained from the foot of the same hills at Twin Springs, 6 miles farther south:

Zaphrentis ? *Stansburyi*.
Lithostrotion ——— ?
Rhombopora ——— ?
Polypora ——— ?
Chonetes ——— ?
Spirifirina ——— ?
Euomphalus ——— ?
Crinoidal fragments.

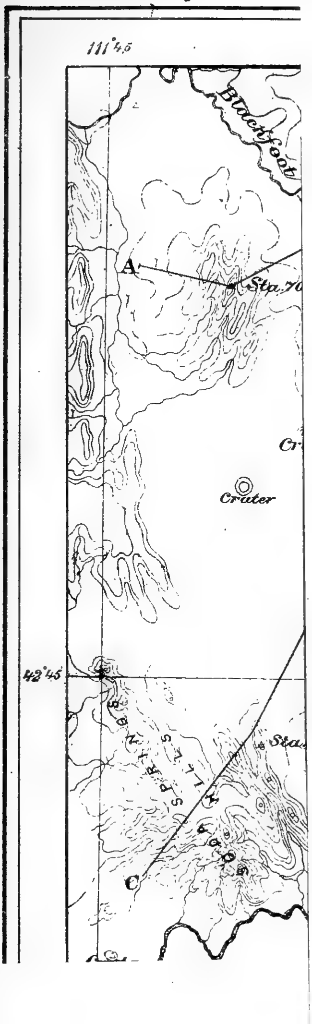
The latter are probably from a lower layer than those first given. The hills on the west side were not visited, but they are probably composed of Carboniferous rocks, with perhaps Jurassic toward the north. At the entrance of the Portneuf to the cañon, quartzites outcrop, dipping to the westward at an angle of 10° to 15°. These quartzites are underlaid by limestones, and form a synclinal depression along the eastern side of the Portneuf Range.

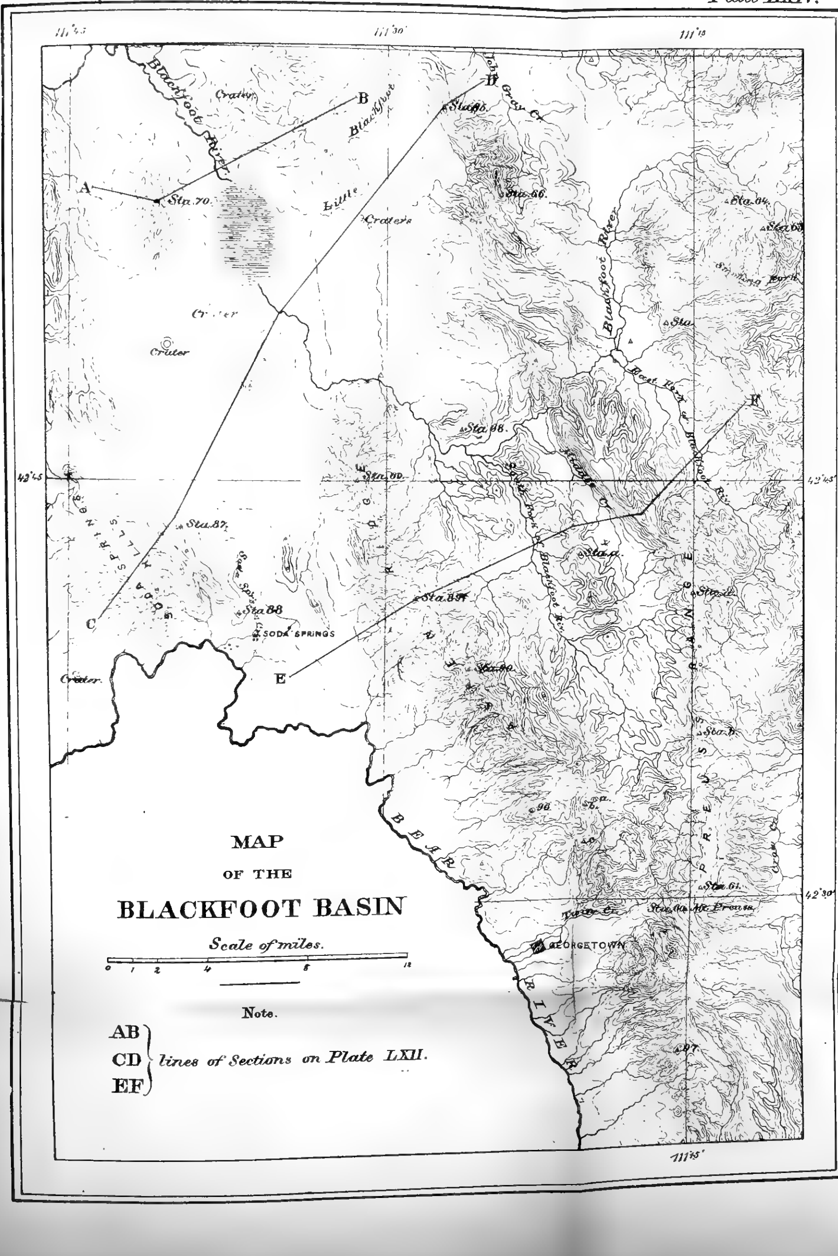
It appears, therefore, that the Upper Portneuf Valley is in part located by an anticlinal fold. No basalt occurs in the northern part of the valley. It is not met with until the Portneuf is crossed. An accumulation of Quaternary drift covers the beds, but judging from the outcrops in Gentile Valley this entire basin was covered by a lake which extended from Pliocene into comparatively recent times. At the end of Pliocene

time, however, there were disturbances which isolated portions of the lake. Considerable disturbance was noted in the Pliocene beds north and south of this locality, and will be noted in other places.

Upper Portneuf Cañon.—As has already been stated, the Portneuf enters the cañon flowing south. It is parallel to the strike of the quartzites that outcrop here, and probably is on the line of an anticlinal axis forming the high part of the range south of the cañon, as the hills west of Basalt Valley show eastward dips. At the head of the cañon the basaltic flow comes to the river, and continues through to Marsh Creek Valley. It is, however, frequently covered by the local drift. As the river enters the cañon it is flowing south, but it curves a little eastward as it approaches the bend. Above the bend, on the west side, white sandstones show, probably of Pliocene age. In the angle stands a high butte of limestone, probably the remnant of an anticlinal ridge. Below the bend the basalt shows more plainly, and on the south side a tunnel has been cut into the side of the hill which shows two layers of basalt separated by a sandy layer containing rounded bowlders. All along this portion of the river there is a great abundance of calcareous tufa which extends out into the river, often forming dams which cause numerous waterfalls from 5 to 20 feet in height. In this part of the cañon also, as we proceed down it, the basalt is seen outcropping now on one side and again on the other, but it probably underlies the whole valley. As the river emerges from the cañon it is seen on both sides, but a short distance below it is found only on the west side extending westward to Marsh Creek. The descent of the river from the mouth of the cañon to the bend at the mouth of Marsh Creek is quite rapid, and the basalt forms a rapidly increasing bluff on the west side. On the east side, a few miles below the bend, an outcrop of lake beds containing fresh-water forms (*Planorbis*, &c.), allied to existing forms, was noted. There are also isolated outcroppings of limestones and shales. It is probable that the lake beds just noted once covered the entire surface, but have been eroded away. The drift from the hills has covered the beds so that difficulty is experienced in trying to determine their exact relations. The basalt ridge breaks off before the mouth of Marsh Creek is reached, and the angle between the mouth of Marsh Creek and the Portneuf has an isolated hill 400 or 500 feet high, in which limestones outcrop. North of the bend yellow, purplish, and gray quartzites and shales outcrop, inclining at high angles, indicating the presence of an anticlinal axis. This is probably the same axis noted just south of the bend of the Portneuf, which will be described under the head of Marsh Creek. The centre of the anticlinal appears to be composed of dark drab slates, either Cambrian (Lower Silurian) or Huronian. Above the slates are purple and gray quartzites. A short distance beyond, the dip has changed and is again to the northeast; and we cross a great thickness of quartzites and slates. These beds are exposed in the section of Station 79, and will be described under the head of the Bannack Range. They form an anticlinal ridge, across which the river cuts to the Snake River plains. The basalt ends in several tables before this anticlinal is crossed, but it appears again below at a lower level. Whether the source is the same for both it is impossible to say. The lower outcrop appears to be connected with the flow of the basalt in the Snake River plains. In this portion of the valley, also, white sandstones make their appearance on the flanks of the hills outside of the basalt. They resemble those seen at the upper part of the Marsh Creek Valley, but whether or not they are the same beds I am unable to say. I am inclined

U. S. Geological Surv




MAP
OF THE
BLACKFOOT BASIN
Scale of miles.
0 1 2 4 8 12
Note.
AB
CD
EF
lines of Sections on Plate LXII.
Blackfoot River
Crater
Little Blackfoot
Sta. 70
Sta. 66
Sta. 64
Sta. 87
Sta. 88
Sta. 89
Sta. 61
SODA SPRINGS
BEAR RIVER
GEORGETOWN
Twin Cr.
Mt. Preuss
PREUSS RANGE
East Fork of Blackfoot River
South Fork of Blackfoot Riv.
John Gray Cr.
A
B
C
D
E
F
111°45'
111°30'
111°15'
42°45'
42°30'

to consider them as older—probably Pliocene. They are disturbed, dipping to the northwest at an angle of from 25° to 30°. The terraces, as Professor Bradley says, show no evidences of any local disturbances. I am inclined to think that the gap in the Bannack Range, which separates Marsh Creek Valley from the valleys to the westward, marks the point where the great lake filling the valleys to the southward had its outlet. One of the two anticlinals formed the barrier which separated the southern lake from the lake that filled the Snake River plains. After the barrier was worn away the cañon was the bed of a great river whose head was at Red Rock Gap, the lake occupying Marsh Creek Valley having been completely drained. This river seems to have removed the late deposits in the cañon probably on account of its more rapid flow in this portion of its course. This subject will be referred to again.

Lower Valley of the Portneuf.—As the valley south of the cañon properly belongs to the upper end of Marsh Creek Valley, I shall take it up there. Below the cañon it merges gradually into the Snake River plain. Basalt here, as we have seen, appears to have spread from the Snake River plain up the valley of the river.

MARSH CREEK.

This stream is the principal branch of the Portneuf, and the only one that will receive a special consideration here. It is a small, sluggish stream, flowing in a muddy channel with swampy banks, back of which are broad meadows. The valley at its head is about a mile in width on the immediate stream; this increases to four or five miles as we descend, and again decreases as its mouth is approached. Outside of this immediate bottom, bounded by the terraces, the valley is from ten to twelve miles in width above the mouth of the Portneuf Cañon. Below this point it decreases to about four miles between the bounding ranges. This valley is underlaid by lake deposits covered with gravel and drift from the surrounding mountains. The sources of Marsh Creek are in the southern end of the Bannack Range, in the northern part of the Malade Range, and in the southern end of the Portneuf Range. The extreme head in the latter is opposite a branch of the Portneuf that joins the river in the cañon. This branch of Marsh Creek flows south, cutting through white friable sandstones, that are almost horizontal in position. At Red Rock Gap it turns abruptly westward, and flows to the northwest through Red Rock Gap. The latter is a pass between two masses of limestone that outcrop from beneath the modern sandstones. The East Rock is the most prominent and rises 280 feet above the creek. South of the pass the divide between Marsh Creek and the waters of Bear River is a swamp, in which it is difficult to tell which way the water goes. From Red Rock Gap, Marsh Creek flows northwestward in a broad, rather marshy valley, bordered by terraces cut in the sandstones that fill Marsh Creek Valley. There are three of these terraces—the lowest 50 feet high, the second 150 feet, and the highest rising about 300 feet above the creek. When the creek reaches the western side of the valley it turns northward, bending somewhat toward the east and joining the Portneuf about 24 miles north of the bend. In all this course the descent of the stream is very slight. The descent from Red Rock Gap to a point 26 miles farther north, as the creek is followed, averages only 1.07 feet per mile. In the bordering terraces the sandstones underlying are seldom exposed, being covered with alluvium and drift. The first thought on seeing these terraces is, that once a large stream must have carved

them. This was recognized by Professor Bradley in 1872. In his report for that year he says (p. 203):

These terraces are very strongly marked through the whole length of this valley; and an upper one is readily identified, though not so prominent, at the level of about 1,000 feet above the stream. They are on too large a scale, and the valley is too wide to have resulted from merely the drainage of the small area of mountains about the head of the stream, and I am strongly of the opinion that this must have been at one time the channel for a large outflow from the Great Basin.

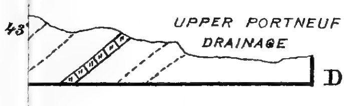
Mr. Gilbert has in several places stated that this pass is the ancient outlet of Lake Bonneville.

In an article in the American Journal of Science and Arts (vol. xv, June, 1878, p. 439) I stated my belief that it was the outlet of a lake having a lower level than Lake Bonneville, as the shore-line of Lake Bonneville as indicated by the Bonneville Beach is about 100 feet higher than the top of the pass. The level of the Provo Beach indicates it to have been the lake drained by the river which cut the terraces in the deposits of Marsh Creek Valley. I shall, however, have to defer the further consideration of this to a subsequent chapter.

Several terrace lines can be traced as continuous from Cache Valley into Marsh Creek Valley south of the pass. One of these is very high, and on the east side of Marsh Creek Valley, south of the exit of the Portneuf, this high terrace is quite distinct. Its level is above the general level of the valley. This is probably the same indicated by Professor Bradley in the extract quoted above. It marks in its outcrops the anticlinal that is seen north of the bend of the Portneuf. Evidences of it are seen also at Red Rock Gap. On the west side white quartzites outcrop dipping west, and on the east side above these quartzites are dark-blue limestones (probably of Quebec age).

The general elevation of Marsh Valley ranges from 5,000 in the middle to about 5,140 feet at the sides. The southern edge of the basalt is not reached until we get within about four or five miles of the exit of the Portneuf from the cañon. Here it appears to have its least thickness. It increases as we descend, showing that, previous to its outpouring, the valley sloped to the northward. This is indicated also by the shape of its surface. The top of the basalt is lower in level than the top of the lake deposits on the west, showing that they were eroded partially, at least, before the basalt was poured out. No basalt is found on the west side of Marsh Creek. It seems, therefore, that the pouring out of the basalt crowded the large stream which then occupied the valley to the west side and forced it to excavate its valley from the soft beds of the west side along the west edge of the basalt. Marsh Creek and the Portneuf probably once united at a point just west of the exit of the latter. When the basalt was poured down the cañon it naturally took the channel formed by these two streams, as it was the lowest portion of the valley. The river occupying Marsh Creek Valley was probably too large to be entirely obstructed by the basalt which must have been somewhat cooled at this distance from its source. That it was partially obstructed is probable from the fact that a large bay-like valley is now found just above the southern limit of the basalt. No beds are exposed below the basalt, which seems to imply that little erosion has taken place since its pouring out. This could certainly be predicated did we know that the bottom of the basaltic bluff is the lowest part of the basalt. The basalt, however, was certainly poured out after the draining of the lake that occupied Marsh Valley and before the complete draining of the lake whose barrier was at Red Rock Gap. There is plenty of room for more study in this region.

U Plate LXV.



e

by Mr St John.

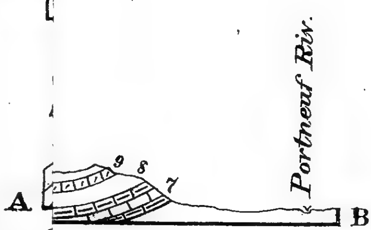
gion.

gion.

24 miles.

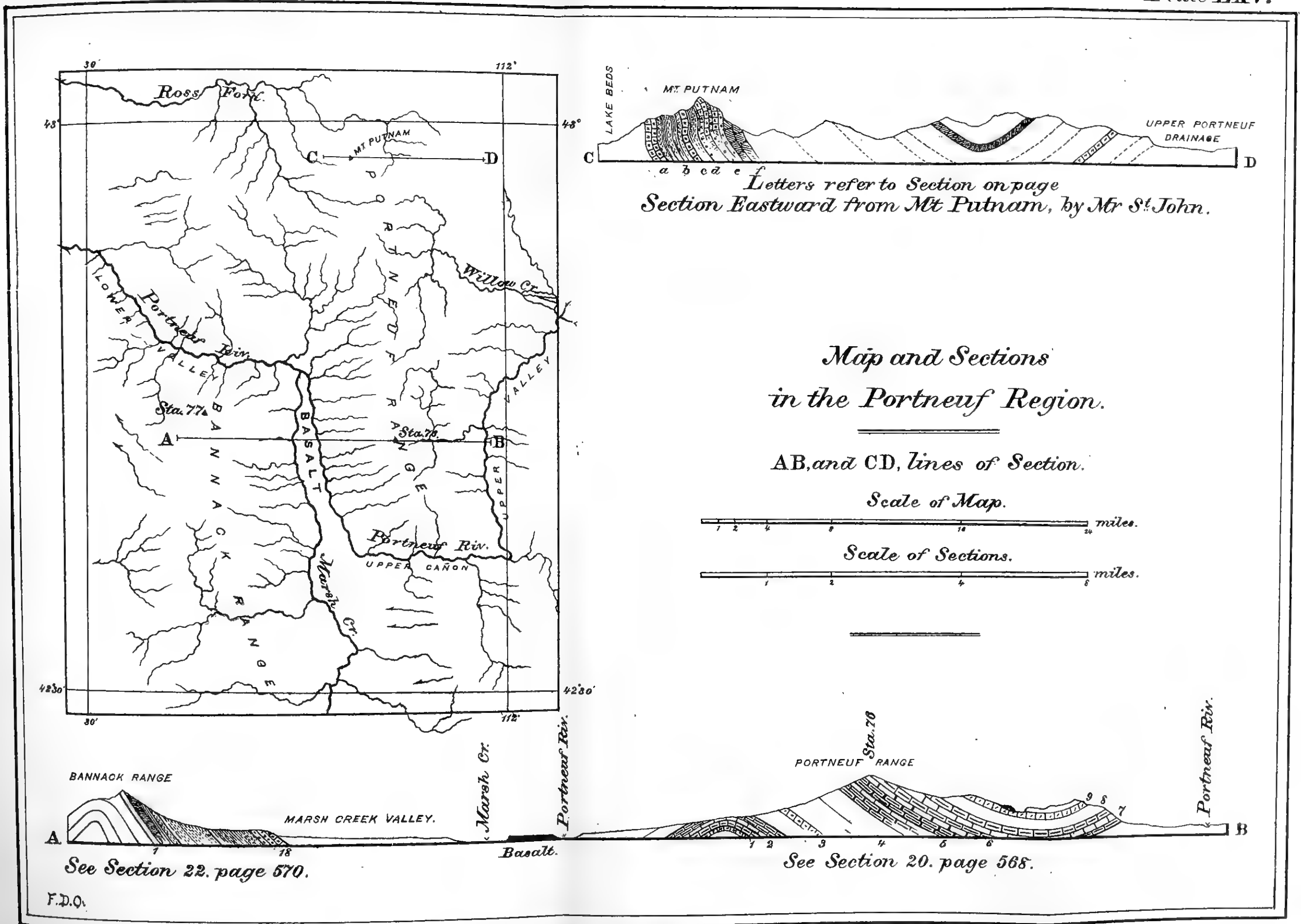
8 miles.

42°30'



S

F.D.



Section Eastward from Mt Putnam, by Mr St. John.

Map and Sections in the Portneuf Region.

AB, and CD, lines of Section.

Scale of Map.

Scale of Sections.

See Section 22. page 570.

See Section 20. page 568.

The descent of the Portneuf to the mouth of Marsh Creek is much more rapid than the descent of Marsh Creek. The bed of the former was probably raised by the basalt, and it was obliged to cut a new bed on the east side of the valley to join Marsh Creek at the narrower portion of the valley.

As to the age of the beds, all that can be said at present is little. Fossils were obtained from them on the Portneuf in 1871, but they were forms that might be of very late Tertiary age or of Quaternary age, being undistinguishable from existing forms. We have seen that the beds have not been disturbed since their deposition. They are older than the deposits found in the centre of Cache Valley on Bear River, and they differ in character from the disturbed Pliocene beds that are found in Cache Valley and in Malade Valley, and are evidently more modern. I believe they were deposited in the same lake that occupied this valley, Cache Valley, Salt Lake Valley, and the valley of the Upper Portneuf, and of Bear Lake Valley. When the Marsh Creek portion of the lake was drained the deposition of sediments continued in Cache Valley, covering the deposits of the same age as those in Marsh Creek Valley wherever the lake extended.

PORTNEUF RANGE.

The Portneuf Range extends southward from Ross Fork between the Upper Portneuf Valley and the Lower Portneuf Valley, to the cañon of the Portneuf, which is at right angles to the trend of the range. This constitutes the northern portion of the range, which is naturally divided from the southern. The latter extends south from the Portneuf Cañon to the northern end of Cache Valley, with which it really ends as a distinct range, although geologically it is connected with the Bear River Range by a mass of low hills, in which rocks of Silurian age outcrop, and through which Bear River cuts its cañon from Gentile Valley to Cache Valley. The northern portion of the range culminates in Mount Putnam. On Mount Putnam white quartzites outcrop at the south end, and at the north end shaly limestones. On Station 76, at the south end of this northern portion of the range, gray and blue limestones outcrop dipping to south 75° east at an angle of 30°. This angle increases towards the north, and on Mount Putnam it is 80° to 85°.

Below the limestones of Station 76 are quartzites, according to Professor Bradley (Report for 1872, p. 204), and below them limestones of the Quebec Group. Below the latter occur the quartzites, in which the anticlinal fold west of the Portneuf is marked as shown in the accompanying section. The continuation of the section westward will be considered under the Bannack Range. East of Station 76 dark-blue limestones with red and yellow bands rest upon the lighter-colored limestones of the station, and above them a white quartzite. The latter appears to form the floor of a synclinal depression; for as we approach the Portneuf we find it rising and dipping gently to westward, the angle of dip being 10° near the Portneuf. In the synclinal depression resting unconformably on the quartzites is a conglomerate, made up of angular fragments of limestone. The outcrop was seen only at one point and appeared to be horizontal in position, and is probably of the same age as the conglomerate at the top of the lake deposits in Gentile Valley.

The Portneuf Range here is, therefore, seen to be monoclinal, with an anticlinal axis a short distance to the westward and a synclinal depression to the east, which has been occupied by an arm of the lake that once filled the Upper Portneuf Valley.

The following is the general section from the base of the range:

Section No. 20.

1. White quartzite.
2. Thin-bedded, somewhat cherty limestones. From these beds Professor Bradley obtained characteristic Quebec fossils in 1872.
3. White quartzites.
4. Space in which beds were not noted.
5. Dark-colored limestones.
6. Dove-colored banded limestones outcropping on Station 76.
7. Light-colored laminated limestones.
8. Very dark blue limestones with reddish and yellow bands.
9. White quartzites.

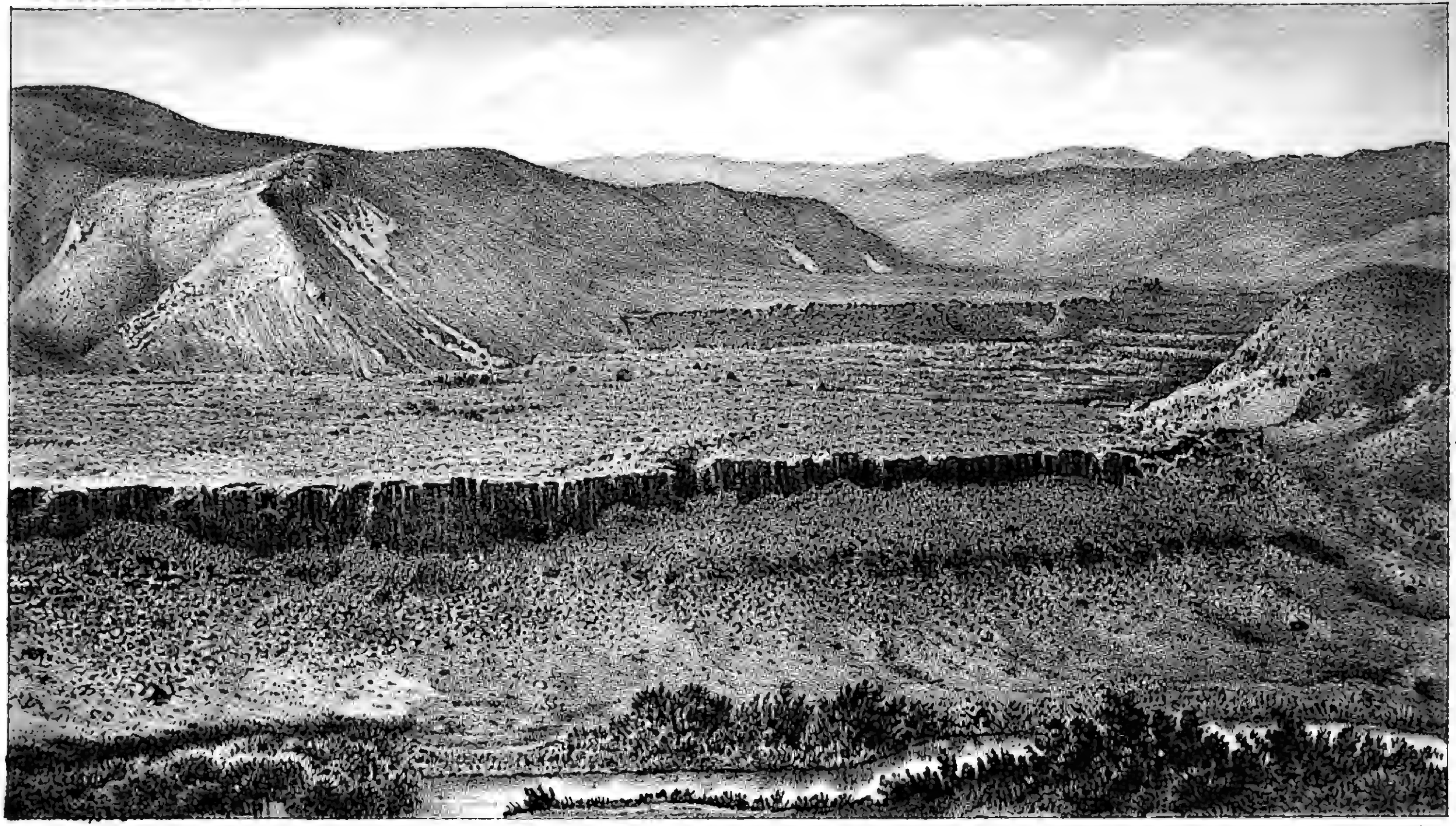
The upper limestones and the white quartzites (No. 8) should probably be referred to the Carboniferous formation, while all below is probably of Silurian age.

South of the cañon of the Portneuf the mountains consist of several parallel ridges somewhat lower in elevation. The entire mass is much broader than that to the north. We had but few stations in them, and these mainly towards the south end. Near the south end of the most western of these ridges (the one overlooking Marsh Creek Valley) Station 133 was located on limestones dipping north 87° east. The general strike, as we looked north, appeared to be about north 5° west. The angle of dip was 30° to 35°. The following section was made:

Section (*No.* 21) *at Station* 133.

Top.	Feet.
1. Blue limestone	130
2. Laminated blue limestones, with *Conocoryphe*, *Dikelocephalus*, *Obolella*, and two species of *Bathyurus*	
3. Bluish-gray limestones	315
4. Laminated limestones, with bands of greenish shales in the upper portion. The limestones are separated by shaly layers. The limestones are fossiliferous at the base, containing quantities of a Trilobite like *Conocoryphe*. The limestone resembles an oolite, but the structure is probably due to the presence of some peculiar organic remains. Fragments of *Discina* are seen	
5. Rather massive limestones	
6. Laminated blue limestones, in bands of from one to two inches thickness, the surfaces of which are yellow-stained	120
7. Rather massive limestones	
8. Green shales or slates, 15 feet	
9. Bluish-gray limestone	118
10. Bluish limestones, with bands of shales	155
11. Massive blue limestones. The dip here appears to be about 40°	100
12. Laminated limestones with interlaminated green shales	70
13. Greenish sandstones and shales, passing below into silvery-gray slates	210
14. Slates and shales with a band of limestone about the middle	185
15. Blue limestones with irregular structure. The strike is about south 5° east, and beyond the station it appears to curve to the south; dip is 60°	70
16. Rusty yellow quartzite	150
17. Gray and yellowish quartzites	450
18. Greenish-gray slates	180
19. Rusty-yellow quartzite, somewhat conglomeritic and containing a considerable percentage of iron	130
20. Rusty quartzites, about	600
21. White quartzites	
22. Pink and white quartzites	500 to 600
23. Red slates, thickness not taken	
Total	3,483-3,583

Below this last layer there are probably the limestones of the Red Rock Pass, which I think lie above the quartzites of Station 132,



Thos. Sinclair & Son, Lith.

BASALT IN LOWER PORTNEUF VALLEY

which themselves are just above the dark-green slates that in all probability represent the Cambrian, as named by King, in the region south and west of our district.

Between layer 23 and the limestones of the pass perhaps the section of Station 77 may be found, unless the quartzites just above are identical with those of Station 77, in which case only the chloritic slates and gray micaceous shales of Station 77 are wanting. This, I think, is the most probable view, as there is probably room for them below this section. The strike of the beds in the section just given must swerve somewhat to the westward as we follow the range northward, so as to fall beneath those of the summit of Station 76.

Station 117 was on the ridge next east across Cottonwood Creek. This station was not visited by me, but Mr. Gannett brought in a piece of hard, red micaceous sandstone, which forms the summit of the ridge. Whether this upper valley of Cottonwood Creek is a monoclinal valley or an anticlinal, I am unable to say. It appears to be filled with Tertiary limestones and sandstones, which appear to extend high up on the ridge of Station 117. North of the latter station quartzites form the summit of the ridge, showing eastward dips. Above these quartzites are laminated limestones, above which are the quartzites of the hills west of Basalt Valley. These all show eastward dips. I am inclined to think there is an anticlinal and synclinal between the eastern and western ridges. On the west side of Gentile Valley, on a station about three or four miles above the head of the cañon of the Bear, a red quartzite, similar to those in Marsh Creek Valley, outcrops, with a western dip. There must, therefore, be a synclinal depression along the eastern side of the range at this portion of its course, but it has been so much eroded that it is obscure. Its position indicates that it is a fold east of the one noticed at the entrance of the Portneuf to the cañon from the upper valley.

Station 131 was located on a hill some eight miles southeast of Station 133, beyond the end of the range, and I refer to it here only because there are outcrops of limestone on it which show eastern dips. On a ridge running south from the station red quartzites outcrop, dipping east, or perhaps a little north of east. The rocks on the station are dark-blue limestones, but whether above or below cannot be positively stated. They are probably above, however, and the quartzites are in that case the same as those in the lower portion of the section of Station 133. The Tertiary (Pliocene?) beds in this region lie between and obscure the older beds lying between the two stations. Quartzites also outcrop in the valley of Swan Lake, and are probably the same as those near the station. It will be evident from what has been written that our data in relation to this lower portion of the Portneuf Range are somewhat meagre. All we can say is that the western portion is composed of Silurian rocks, while toward the eastward the Carboniferous formation may be present. There are probably several folds which enter into the formation of the mountains. The axes of these folds have their directions a few degrees west of north and east of south. The range formed the boundary between the lake that filled Marsh Creek Valley and the lake of Gentile Valley and its northern extension, Basalt and Upper Portneuf Valleys. There was probably a connection between these lakes through the Portneuf Cañon, and when the lake was at one of its highest levels one arm occupied the synclinal just east of the main northern portion of the range.

The highest peak in the range is Station 76, with an elevation of 9,115 feet. Mount Putnam at the northern end has an elevation of 8,933 feet. The slopes on both sides of the range are steep and rugged.

BANNACK RANGE.

The summit of the Bannack Range was the western limit of our work. It extends along the western side of Marsh Creek Valley, above which its highest peaks rise a little over 4,000 feet. The range consists of two somewhat isolated mountain masses eight or ten miles apart. They are connected, however, by a low ridge, so that, geologically, the range is continuous. The portion between the two masses was not visited. In the northern portion two stations (Nos. 77 and 78) were located, one of which was visited by me, and in the southern portion Station 135 was located.

The cañon of the Portneuf, cut across the northern end of the range, shows it to be a well-defined anticlinal, quartzites, slates, and limestones outcropping there, and showing dips in east and west directions, as already noted in a preceding portion of this chapter. All the beds outcropping in the cañon that enter into the fold are highly metamorphosed. The same beds are shown on the eastern slopes of Station 77, where the following section was made:

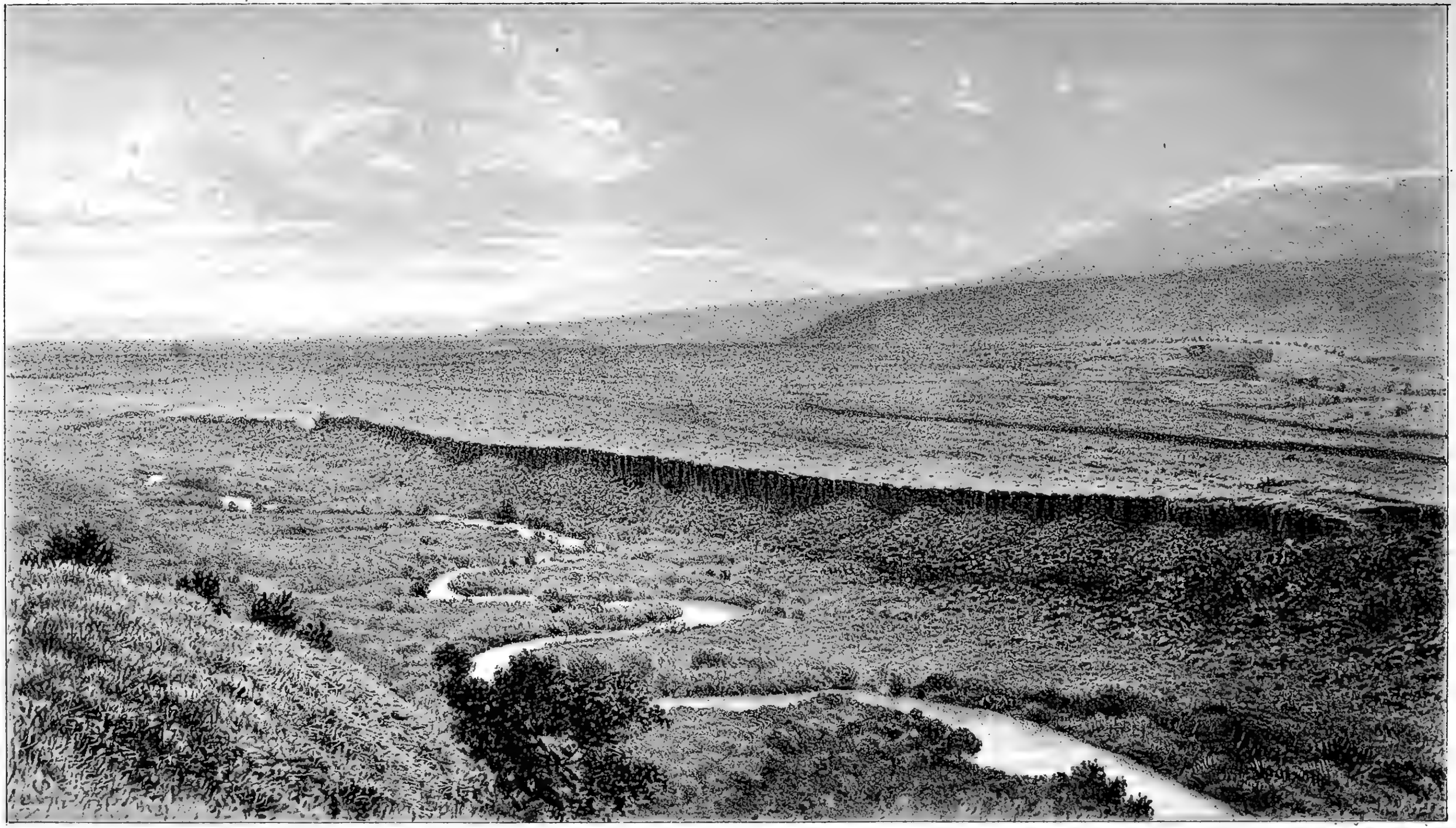
Section No. 22, from Station 77 eastward.

Base.	Feet.
1. White quartzite	
2. Light-yellowish argillaceous slates, in laminæ of about a quarter of an inch thickness, with pyrite	
3. White quartzite	1,600
4. Sombre metamorphosed quartzitic sandstones, with rounded quartzitic pebbles. Most of the sandstones are of a dark-greenish, almost black color, with grayish layers made up largely of grains of quartz	
5. Dark-gray quartzite	
6. Silvery gray micaceous slates	
7. Laminated gray slates	1,900+
8. Gray micaceous slates	
9. Green and gray chloritic slates, quartzitic	
10. Olive-green chloritic slates, with smooth surfaces. On some of the layers there are indistinct mud markings and other markings somewhat resembling fucoidal remains, although they may be the result of imperfect borings by worms	1,560+
11. White quartzite	
12. Greenish-gray indurated argillaceous slates and shales, with bands of gray and white quartzites	
13. Gray and yellow hard limestone in two bands; these limestones are covered, and were recognized from a few obscure outcrops	
14. Quartzitic argillaceous slates	
15. White quartzites	
16. Pink quartzites; some of these are conglomeritic and have the appearance of metamorphosed conglomeritic sandstones; some of the layers are quite red in color	650+
17. Yellowish slates	
18. Pink quartzites; some of the layers of these quartzites are green on the surfaces or planes of separation	
Total	5,710+

In layer No. 2 cubical crystals of oxide of iron are numerous; some of them are nearly two inches on a side. These beds are probably the same that have been referred to the Cambrian by Emmons and Hayne in their districts south of ours.

In Box Elder Cañon, on the western side of the Wahsatch Range, almost due south of the locality of the section given above, they consist according to Hague* of quartzites and siliceous slates, with some mica-

* U. S. Exploration of the 40th Parallel, Vol. II, p. 403.



Thos. Sinclair & Son, Lith.

BASALT IN PORTNEUF VALLEY — LOOKING SOUTH.

ceous schist. I think there is no doubt that the beds are identical. The dip of the beds in the section just given is approximately east, at an angle of 55°. The strike therefore must be about north and south. This probably curves a little to the eastward toward the south, as we find near the divide to Malade Valley an anticlinal axis which is in all probability the same noted in the cañon of the Portneuf. The axis of the range, therefore, lies to the west of the station, and the beds must sink as we go south, for the southern part of the range is made up of the limestones that lie above these quartzites. Station 78, just south of 77, is on the micaceous slates that lie below the quartzites and chloritic slates. It is a couple of hundred feet higher than Station 77. South of Station 78 a long ridge connects the northern portion of the range with the southern, on which Station 135 was located.

Station 135 is on limestones that are probably Silurian. Toward the base quartzites outcrop, probably the top of the Cambrian. The dip on the station is about west. On the slopes leading to the station there appears to be some curving in the strike, so as to make the dip more to the southward or southwest. On the east side of the Malade Divide the dip appears to be from North 17° East to North 27° East.

Between the two points, therefore, there must be an anticlinal axis which, I think, is the same as that of the northern part of the Bannack Range. The lowest outcrop noted on the east is a white quartzite, above which are irregular-structured limestones. They soon disappear as we get down into Marsh Creek Valley. Bradley considered these limestones as belonging to the Quebec Group.* I found no fossils in the beds, but they are probably the same as the limestones outcropping south in Malade Valley, back of Malade City. The mountain mass west and south of Station 135 may be partly Carboniferous—the continuation of the Carboniferous south of Samaria, yet to be described however. The western side of the range and the valley beyond were not examined, and this opinion is, therefore, merely conjecture.

North of the Portneuf Cañon the prolongation of the Bannack Range is a ridge forming the western portion of the hills west of Mount Putnam. On these hills the outcrops are obscure; on Station 80 a gray quartzite shows which is the continuation of one of the quartzites farther south. The dip could not be determined. North of the station the Cambrian beds seem to disappear beneath Tertiary (Pliocene) deposits, which form the hills south of Ross's Fork of Snake River. They, however, form cappings, for at several places outcrops of limestone were seen protruding above the light, white, and reddish Tertiary beds.

On Station 81, eight or nine miles north of Station 80, basalt is found on the summit of the hills bordering the valley of Ross's Fork and that of Snake River. This basalt dips at quite an angle toward the valley, and on some of the hills appears to be horizontal. The Tertiaries also show dips toward the valley of Snake River. South of Station 81 a hill shows outcrops of blue limestone, probably Silurian, with a northern dip. All about the hill Tertiary limestones and sandstones outcrop, concealing the older beds. The basalt appears much older than the basalt of Marsh Creek, and its position on the Tertiary (Pliocene?) proves it older. It was probably uplifted with the underlying beds, which places its age as subsequent or just at the close of the Pliocene. The source of this basalt is probably some point in the Snake River plain. Basalt is also found in the valley of the Portneuf, extending up the valley from the Snake River Valley. This basalt of Station 81 is older. In the former, Professor

---

*Report U. S. Geol. Survey, 1872, 1873, p. 203.

Bradley mentions proof of two eruptions,* the layers of which are separated by sand and gravel. I am inclined to think the basalt of Station 81 is older than either of the layers mentioned by Professor Bradley. North of Ross Fork the axis of the Bannack Range disappears entirely beneath the accumulations of Snake River plain.

We have seen, therefore, that the Bannack Range is one of the isolated ranges so common in the region of the Great Basin, and like the others is a remnant of a system of folding. The northern portion shows one side of ananticlinal, while the southern portion shows the other. Erosion has removed a great mass of beds, and the valleys on either side are filled with later lacustrine deposits. There is no evidence, either in this range or in the Portneuf Range, of the faulting noticed by King in the main Wahsatch Range, and the absence is further proof that the faulting in the latter took place after a period of complicated foldings, as held by King.† I shall refer to this point again in a subsequent chapter when speaking of the district as a whole.

* Report U. S. Geol. Survey, 1872, 1873, p. 204.
† Exploration of the 40th Parallel, Vol. I, p. 735.

CHAPTER V.

DESCRIPTIVE GEOLOGY—BEAR RIVER DRAINAGE AREA.

BEAR RIVER—UPPER BEAR RIVER VALLEY—SMITH'S FORK—SUBLETTE RANGE—THOMAS' FORK—BEAR LAKE PLATEAU—BEAR LAKE VALLEY—PREUSS RANGE—SODA SPRINGS AND BEAR RIVER BEND—SODA SPRINGS VALLEY—SODA SPRINGS HILLS—BASALT VALLEY—BEAR RIVER RANGE—GENTILE VALLEY—MIDDLE CAÑON OF BEAR RIVER—CACHE VALLEY—MALADE RANGE—MALADE VALLEY—BLUE SPRING HILLS.

The present chapter will be devoted to the description of the southwestern portion of the district, in which the drainage is tributary to Bear River. It is therefore a portion of the Great Basin. Bear River is the great artery of this whole region. In considering it I shall follow the plan of the preceding chapter, and shall take up the successive streams, alternating with such mountain ranges as intervene. The entire area drained by the Bear and its branches within our district is nearly 5,000 square miles, or over one-third of the entire district surveyed by us during the season.

BEAR RIVER.

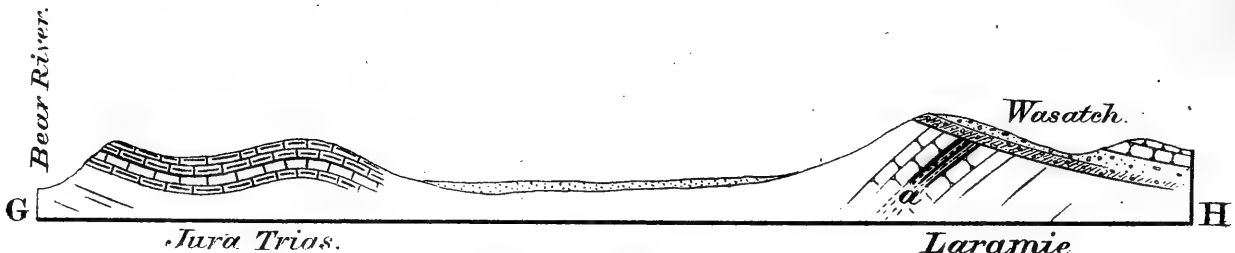
Bear River enters our district in about longitude 111°, flowing sluggishly with large curves through a broad valley which continues northward to the mouth of Smith's Fork, a distance of about 25 miles on a north and south line. From this, which we call the Upper Valley, it turns slightly to the northwest into a narrower valley which reaches to the mouth of Thomas' Fork. Receiving the latter stream in a broad valley opposite the Sublette Range the river turns abruptly to the southwest, and enters the cañon-like valley at the north end of the Bear Lake Plateau, through which it cuts to the valley of Bear Lake. In this cañon it turns abruptly to the north, making a right-angled bend. The valley in the cañon is generally broad and meadow-like with good grass. Several ranches have been located below the bend and seem to be flourishing. Soon after the river comes out into Bear Lake Valley it loses itself in the marsh that extends northward from Bear Lake. Below the marsh the river flows through a wide marshy flat, covered with a growth of coarse grass. The soil in this region is rich and the valley has been well settled. Numerous towns are found along the river. The course of the river here is approximately northwest until within about 6 miles of Soda Springs, where there is a sharp turn to the westward along the south edge of a basaltic flow. After keeping this direction for about 5 miles a northern course is assumed and the river curves to westward and southwestward in the valley opposite the mouth of Soda Springs Creek. Four miles west of the mouth of the latter the Bear cuts across the northern end of the Bear River Range at the south side of a gap that is about half a mile in width. Here it is in low cañon, a basaltic wall bounding it on the north and the limestones of the range outcropping on the south bank. For three or four miles beyond the gap the river keeps close to the foot of the range. The cause of this may, perhaps, be seen in the basaltic flow which came from the craters still

existing west of the gap. The river, however, soon turns to the westward and cuts a deep cañon in the basalt, which, continuing northward, forms the floor of Basalt Valley. The cañon is about 300 feet deep on the west side of the valley, and the river flows through it, broken by falls and rapids. At the western side of the basalt-field the river turns to the south, making a right angle in its course, and soon flows out of the cañon, skirting the western edge of the basalt, into the northern end of Gentile Valley. The general course of the river in Gentile Valley is south. It is broad and flows sluggishly between broad meadows that are bounded by soft lacustrine deposits. Leaving this valley the Bear enters a deep cañon cut in Silurian limestones. This cañon, which I shall call the "middle cañon of Bear River," is nine miles in length and divides Gentile Valley from the upper end of Cache Valley. On entering Cache Valley, the river turns to the westward, keeping a course a little south of west for nine miles. Again it turns southward, a course which it keeps until it approaches Cache Butte, when it turns to the southeast, flowing sluggishly with inclosed islands and broad meadows. It keeps this direction for only three or four miles, once more resuming its southern course. About two miles above the mouth of Logan River it turns to the northwest, and about five miles below the mouth of the latter stream it enters the "gates," from which it flows out into the lower end of the Malade Valley, and leaves our district in longitude 112° 8′, to flow southward to Bear River Bay of the Great Salt Lake. The eccentric course of Bear River will be better appreciated by a glance at the map. The river is seen to have two general courses, one northern and the other southern. The most northern point reached is at Soda Springs. The Bear River Range separates the two portions of Bear River as thus described. I shall now take up the different portions of the Bear, considering the general geological structure of its various valleys and the geology of the bounding ranges.

UPPER BEAR RIVER VALLEY.

The Upper Bear River Valley, as I have already defined it, extends from the mouth of Smith's Fork, southward, to the limits of our district. Beyond this it reaches nearly 30 miles to the southward. Its length in our district is 25 miles in an air-line direction. It is from three to four miles in width, and of rather uniform surface, covered with abundant good grass. The general elevation is 6,250 feet. The Bear flows through this broad bottom in curves, with an extremely sluggish current, over a soft, sandy, and muddy bed, which is so treacherous as to afford few good fords, although the river is neither very wide nor deep. Alluvial deposits and local drift from the bounding hills conceal the strata underlying the valley. The two principal streams joining the Bear from the west side in this upper valley are Twin Creek and Sublette's Creek.

Twin Creek.—Twin Creek joins the Bear a few miles above our south line. The upper portion has been considered under the head of "the Ham's Fork Plateau." Leaving the upper valley, which is cut in the variegated beds of the Wahsatch Group, Twin Creek enters a cañon cutting across a high ridge of Carboniferous and Jurassic rocks. Soon after entering the cañon it is joined by its northern branch, Rock Creek, which is the principal stream. Rock Creek occupies a narrow valley at the west side of the ridge that forms the west boundary of the Ham's Fork Plateau and Basin. This ridge is a sharp anticlinal of Carboniferous limestone, which continues northward west of Smith's Fork, where it



a, Coal beds of Section No, 23. page 575.

Section along Twin Creek,

East from Bear River.

F.D.O.

will be again considered. To the southward it ends very soon, and higher beds appear to curve around the end of the ridge over the limestones. On the west side of the ridge the Wahsatch beds, with isolated cappings of Green River shales, rest unconformably on the limestones, and the erosion of this ridge doubtless contributed to the formation of the conglomeritic Wahsatch beds. The valley of Rock Creek is a monoclinal. It is about 14 miles in length, and not over half a mile in width at the widest portion. It is 1,400 feet below the top of the Carboniferous ridge. On the west side is a rather regular flat-topped ridge that rises 1,000 feet above the creek-level. Near the southern end of this a substation was located. The beds outcropping on the east face of the ridge were limestones and quartzites. They were all somewhat obscure, but near the top of the ridge was an outcrop of light yellowish-gray limestone, in which I obtained a few indistinct organic remains, identified by Dr. White, as follows:

Eumicrotis curta?
Myalina whitei?
Aviculopecten idahoensis?
Myacites?
Modiola?

Above these limestones a whitish quartzite forms the summit of the ridge. All the strata dip to the westward.

At one point there appeared to be a capping of Green River shales in horizontal position, resting on the upturned edges of the Jurassic strata, but it could not be defined as the hill was so thickly covered with *débris*. Above the quartzites followed limestones and shales, above which were reddish sandstones and shales, all referable to the Jurassic, according to their position and lithological structure. To the westward these beds disappear beneath the valley of Bear River. Below the mouth of Rock Creek, Twin Creek flows in a broad sage-brush valley. On the north side blue Jurassic limestones outcrop in low bluffs on the edge of the valley, and on them rest Wahsatch sandstones unconformably.

Station 106 was located south of the valley on a hill, in which there were a few obscure outcrops of Jurassic limestone surrounded by Wahsatch beds. A short distance northwest of the station the valley of Twin Creek narrows as it cuts across a low ridge. At this point there is a coal-mine, owned by the Wyoming Coal and Coking Company. The bed was discovered in 1875. There is a tunnel 470 feet in length, with a side shaft 120 feet in length. The following is the section beginning with the coal-bed penetrated by the tunnel.

Section No. 23.

1. Coal, $3\frac{1}{2}$ feet.
2. Shales and slates.
3. Coal, 3 or 4 inches.
4. Clay, 6 feet, decreasing in places to 3 feet.
5. Coal, 6 feet.
6. Light-colored sandstones forming the roof.

These beds dip to the westward or a little north of west, at an angle of about 40°. The sandstones are fossiliferous. The following were obtained:

Rhytophora meekii.
Corbicula (Veloritina) durkeei.
Goniobasis chrysaloidea.
Pyrgulifera humerosa.
Goniobasis chrysalis.
Volsella (Brachydontes) ——— *?*
Ostrea? ——— *?*
Neritina?

These prove the beds to be the same as the Bear River Laramie group.

On the top of the hill in which they outcrop, Wahsatch red conglomerates and sandstones dip 10° to 15° to the eastward. Succeeding these reddish beds are white sandstones.

Underlying bed No. 1 is a considerable thickness of light sandstones, in which there is a thin coal-bed. Sampson Tams, of San Francisco, is president of the company. No work was being done on the mine at the time of my visit. Several buildings have been erected; also an oven for coking the coal. The coal has to be pulverized and washed before coking. This coal-bed is probably the same noted on Smith's Fork, 20 miles farther north. West of the hill in which the coal outcrops is a rather broad sage-brush-covered valley, and then another ridge in which sandstones and limestones outcrop, showing an anticlinal fold, beyond which is a gentle synclinal and the eastern side of a second anticlinal. The latter forms low bluffs facing the Bear. Farther south these beds rise into a high ridge which, on the map of the Fortieth Parallel survey, is colored Upper Carboniferous.* Speaking of this ridge, Mr. Emmons says:† "But little opportunity was afforded for the examination of this somewhat isolated body of limestone, and it has been referred to the Upper Coal-Measure limestone on no palæontological or direct stratigraphical evidence, but solely from its relative position with regard to the Silurian and Cambrian bodies on the west side of Bear River Plateau." I have colored a portion of them Jurassic or Jura-Trias from evidence obtained on Smith's Fork and in the Bear Lake Plateau, which reveals the presence of several folds in the rocks underlying the plateau, which is the northern continuation of the eastern side of the Bear River Plateau. The limestones outcropping in the bluff near Bear River, and which form the prominent ridge to the southward, I have colored Carboniferous, corresponding to the coloring of King's map.

What the exact relation is between the Laramie Group and the Jurassic I am unable to determine with the data from the few points I was able to visit. There appears at some places to be an unconformability, and at others the whole Cretaceous series may be present between them. This region is one that will have to be carefully investigated in considerable detail before it can be determined. The Wahsatch that outcrops east of the coal-mine does not extend far to the northward.

On the east side of the valley, between Twin Creek and Sublette Creek, are several outcrops of sandstone that have been referred to the Laramie Group.

A rough wagon-road crosses from Ham's Fork to the head of Twin Creek, and follows the latter to the Bear. The south side of Twin Creek, at the head, has mesas with cappings of Green River shale that extend southward beyond our line.

Sublette's Creek comes into the Bear 16 miles north of Twin Creek. It heads north of Rock Creek on the west side of the ridge already described. The wagon-road from Green River Valley comes down its southern branch, and when we were in the valley, in June, large droves of cattle were being driven over the road. Near the mouth of the creek there is a small two years old settlement of Mormons. The Upper Bear River Valley makes a good summer range for cattle, but in winter it is necessary to feed at the rate of about a ton and a half of hay per head. While we were in the valley, in the latter part of June, there were heavy frosts every night, and we had a snow-squall about the 1st of July. The settlers say that it was exceptional weather, although they all agree that

* Exploration Fortieth Parallel, Atlas Map III, west half.

† Exploration Fortieth Parallel, Vol. II, page 338.

the climate is somewhat cold. The western boundary of the valley is the Boundary Range, a range of comparatively low hills eroded from the east edge of the Bear Lake Plateau. These hills are composed of the variegated Wahsatch conglomerates and sandstones, bright red colors predominating. They are rounded in outline, and rise some 1,000 to 1,400 feet above the valley, increasing in height toward the north. They will be referred to again under the head of the Bear Lake Plateau.

The western side of the broad valley is covered with gravel outside of the immediate river-bottom. This gravel is derived from the weathering of the conglomeritic sandstones of the Wahsatch Group. There are few settlements in the Upper Bear River Valley in our district. South of our district, however, there are several towns, Randolph and Woodruff being the principal ones.

SMITH'S FORK OF BEAR RIVER.

Smith's Fork enters the Bear River Valley from between two high buttes in a valley less than half a mile wide. Side by side with it is a small creek (Spring Creek) that rises in the ridge east of the bend of Smith's Fork. Just below the point where the two streams come out into the valley there is a small settlement called Coketown. The butte on the south side of the gap was named Station Butte. Station 37 was located on its summit. It is composed of Carboniferous limestones, representing the axis of an anticlinal, which is well shown in the opposite butte, which was named Coketown Butte. The latter is really the south end of the Sublette Range. The strike is north, or perhaps a little west of north. The Carboniferous limestones are very sharply folded, standing on end in the centre of the fold and dipping 80° to the westward on the west side. The following general section was made from the butte eastward to the coal outcrop. The relations will be better appreciated by a reference to the accompanying plate, where the section from Bear River eastward across the bend of Smith's Fork to the range is given.

Section 24, on north side of Smith's Fork.

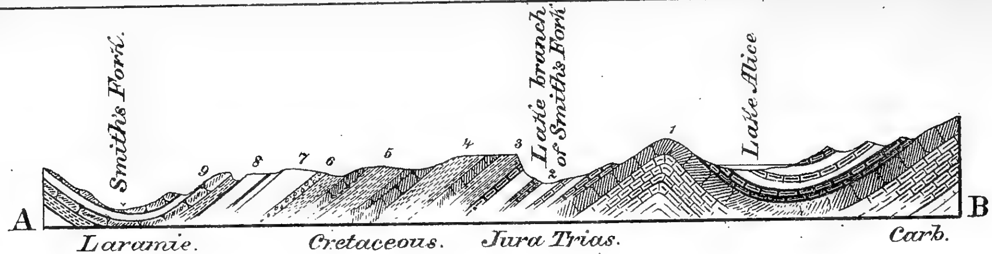
1.	Massive grayish-blue limestones	800 feet.
2.	Blue limestones	
	These two layers comprise a thickness of 500 to 800 feet	
3.	Space covered	500 to 600 feet.
4.	Brown shales, calcareous	
5.	Bluish-gray limestones, containing fragments of an indistinct *Productus*	
5.	Gray limestones and calcareous shales near the top. The following fossils were found: *Aviculopecten idahoensis, Ostrea* ——? *Lingula brevirostris? Myacites* ——? They were all fragmentary and identified with some doubt	
6.	Grayish-brown limestones	
7.	Space covered with reddish *débris*	1,500 to 1,800 feet.
8.	Blue limestone, containing the following fossils: *Eumicrotis curta? Lingula brevirostris? Aviculopecten* ——?	
9.	Covered space	
10.	Grayish limestones	
11.	Space covered by red and gray *débris*	
12.	Greenish-gray sandstones	
13.	Laminated gray sandstones, with black slates	
14.	Greenish-gray sandstones	
15.	Coal	
	Total	2,800 to 3,200 feet.

In bed No. 14, which is rather a poor quality of coal, a shaft has been sunk and a tunnel opened into the bed from below. The former is 80 feet deep and 7 feet in width. The tunnel is inclined and has penetrated

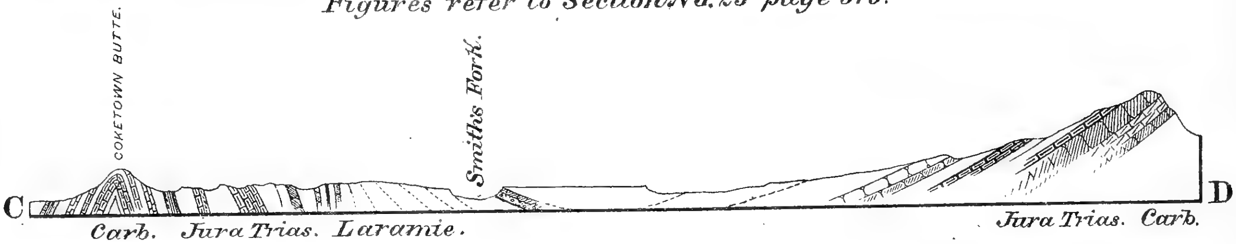
nearly 100 feet. There are several beds alongside of the main bed. They stand almost on end, dipping slightly toward the east. In some of the coaly slate I obtained fragments of *Unio Vetustus*, and a number of undeterminable shells which warrant reference to the Laramie Group. There are two claims located on the bed on the north side of the valley and several on the south side. There is scarcely any doubt that this coal-bed is the same as the one of Twin Creek, and that it should be referred to the Laramie Group. The fossils obtained below are Jurassic, and there would appear to be but a small thickness of Cretaceous present, if any, as the greenish-gray sandstones just above appear to be a portion of the Laramie. Going farther east we find red conglomerates outcropping on Smith's Fork above the bend, with an eastern dip. These sandstones and conglomerates disappear beneath a broad terrace which rises 241 feet above the level of the stream. Back of this terrace, between it and the hogbacks that extend along the range, there is a broad valley, evidently one of the old river-beds for Smith's Fork. South of the bend of the river this terrace does not exist, and the beds that underlie it form a series of eastward-dipping hogbacks. These hogbacks are formed of the reddish and gray sandstones that outcrop farther north in the valley of Smith's Fork. Beneath the sandstones are blue limestones which rise on the range; in one layer a large number of *Camptonectes Stygius?* were observed. These limestones are probably above those in which fossils were obtained west of the coal opening. Below them are the following beds forming the range:

Blue limestones.
Dark-red sandstones.
Light-red sandstones.
Red limestones.
Red sandstones.
Covered space reaching to the level of Pine Creek.
Carboniferous limestones.

The latter are on the east side of Pine Creek. The latter stream rises east of the hogbacks, between them and the main ridge, which is the continuation of the ridge east of Rock Creek. It joins Smith's Fork at the bend. From the bend of Smith's Fork northward to the Forks is about nineteen miles. The course from the Forks is somewhat west of south. In the lower part of the valley, as we have seen, the river is west of the synclinal. As we follow up the river we soon find it occupying the axis of the depression, and it flows between hogbacks which have rather rounded outlines. The few outcrops noted are of gray sandstones. To the westward are high, rolling hills and spurs from the Sublette Range. The only fossils found in the beds underlying the hills nearest to the river were of the Bear River Laramie Group. Just below the Forks the course of the river is somewhat eccentric. After the two forming streams unite, the river flows to the northwest for about half a mile, when it turns to the southwest and comes out into the valley that continues southward. The two branches join in a cañon. Following up this cañon we cross, first, the sandstones that form the hogback along the east side of Smith's Fork. Below the sandstone are shales with a coaly layer. Below are more sandstones and shales, and then a conglomerate somewhat metamorphosed, or seemingly so. It is quartzitic and dark colored, with red and lighter colored pebbles. It has considerable resemblance to the conglomerate of the Dakota Cretaceous. It dips to the westward at an angle of about 30°. No fossils were found near it, neither just above it nor just below, so that its age remains doubtful. Below there is a considerable thickness of shales and sand-



Figures refer to Section No. 25 page 579.



Figures refer to Section No. 24. page 577.

Sections across Smith's Fork of Bear River.

F. D. O.

stones, probably some 4,000 feet in all. The soft character of these beds causes them to weather into rounded hills, in which all the outcrops are obscure.

As far as seen, the beds resemble very closely those seen on the west side of John Day's River, and they occupy the same relative position. If the conglomerate above is Cretaceous the group must be referred to the Jurassic; if not, it may represent the Cretaceous, while the beds above should be referred to the Laramie Group. The continuation of the section west from Smith's Fork would seem to favor the latter view. Until more fossils are found, I shall refer the beds partly to the Cretaceous and partly to the Jurassic, as just below the shales are limestones containing Jurassic fossils, and on John Day's River the limestones containing *Pentacrinus asteriscus* were some distance below the Belemnites bed, which was separated from them by reddish shales similar to those above the limestones on Smith's Fork.

These limestones form a bluff on the Lake branch of Smith's Fork. The exposure of limestones shows a thickness of about 800 feet, and above is a thickness of about 1,800 feet of the reddish shales and sandstones. Near the top of the limestones I found:

Ostrea strigulecula.
Pentacrinus asteriscus.
Tancredia ——— ?
Undetermined *conchifers.*
Undetermined *gasteropods.*

These prove the Jurassic age of the limestones, and they are probably identical with the "Pentacrinus beds" of the section made on John Day's River, near the mouth of McDougal Creek (in the preceding chapter). The limestones form cappings on the slopes of the hills on the east side of the Lake Fork, although they do not reach to the summits, which are mainly of red sandstones. The section as just given in general is as follows, corresponding with the profile in the accompanying plate:

Section No. 25, along Smith's Fork, west from Station 43.

Base:	Thickness in feet.
1. Red sandstones outcropping on Station 43.	
2. Blue limestones containing Jurassic fossils, *Pentacrinus*, &c	800
3. Calcareous shales } 4. Reddish shales and sandstones }	1,800
5. Space covered with *debris* of sandstones and shales	4,000
6. Conglomerate } 7. Sandstone shales and sandstones }	4,000
8. Black shales } 9. Greenish-gray sandstones }	1,300
Total	11,900

The dip is 30° westward, as far as Smith's Fork, which is in the synclinal depression.

Between four and five miles above the Forks the stream is formed by two streams, one of which is called the Lake Branch. It comes from the north, while the Southern Branch comes from the east, draining the region east of Stations 42 and 43. The former is located in the bend of the creek, on a high rounded hill of red sandstones, while station 43 is at the northern end of the same hill. It is on the axis of a fold which is well shown in a high hill a couple of miles farther north. The axis of the fold appears to have a direction somewhat west of north. Toward the south, however, it appears to curve so as to be north and south, and the

topography indicates that it is the same fold shown in the Carboniferous limestones east of Rock Creek. Here, however, the red sandstones (probably Trias) form the surface of the fold. Station 42 is a little to the west of it.

East of the ridge is a synclinal depression, the centre of which is occupied by gray beds identical with the limestones seen in the bluff on the west side of the Lake Fork. They are continuous with them a few miles to the northward, where the anticlinal ridge is lower, and the fold in the Jurassic preserved. I am unable to say how far south this synclinal depression continues. It appears to narrow very rapidly, and probably soon dies out, leaving the red beds to form a broad anticlinal. The latter rise from beneath the gray limestones and form the summit of the range to the eastward. The eastern face of this range, as we saw when describing the head of La Barge Creek, is composed of Carboniferous limestones, presenting a bluff face toward the valley of the La Barge.

North of Station 43 is a beautiful emerald lake (Lake Alice), which has apparently no outlet. It has been formed by a landslide at the mouth of the gorge separating the station hill from the one north. Whatever outlet there is, must be beneath the mass of earth that has dammed up the stream that once occupied this gorge. The lake has no beach. It is five miles long and less than three-quarters of a mile in width at the widest portion. The fold of Station 43 is probably the southern continuation of the western fold of the Salt River Range. Between the two points, however, the reddish shales that lie above the Jurassic limestones outcrop and form the surface. The eastern fold of the range also begins a short distance north of this point, the red beds rising from beneath the gray limestones. The whole region is so complicated that I can only present the most general features. The investigation of these folds will well repay the student of geology, and before coloring the final map of the region I hope to be able to revisit it.

The Lake Branch, as we have seen, has its valley cut almost entirely in Jurassic rocks, and flows south in a monoclinal valley. The main branch has an almost parallel course, rising however, some miles farther north, viz, between the head of La Barge Creek and the extreme source of Salt River. The upper course of the river is in the variegated beds that lie just above the Jurassic limestones. Near the junction with the other fork it is in the shales and sandstones that lie above the conglomerate, layer No. 6 of Section 25. The section west of Smith's Fork will be given subsequently, when considering the Sublette Range and the region of Thomas' Fork.

The valley of Smith's Fork above the bend has but little available agricultural land. The mountains at the head of its various branches are well timbered with pines. The lower valley merges into that of Bear River, and is meadow-like and well grassed, although somewhat high for general agricultural purposes. Some of the settlers seem to think, however, that there has been some change in the climate since the first settlement of this region. No accurate observations have been made, and it is probably only an opinion, with very little fact for a foundation.

SUBLETTE RANGE.

The Sublette Range is a short range of rather rounded form, rising 2,000 to 3,000 feet above Bear River on the east side, extending north between Smith's Fork and Thomas' Fork. The total length of the range is about twenty-one miles. It is divided into two portions by a branch of Thomas' Fork. The northern portion was not visited by us; but judg-

ing from what we saw south and north of it, its component rocks are of Jurassic age, which are folded as they are to the south. In the northern portion of the south end of the range, Station 38 is located. A fragment of a *Zaphrentis* from the station was brought in, which indicates that the centre of the range is Carboniferous. The exposures of rocks are very limited. East of Station 38 Jurassic limestones dip to the eastward, and on the west red sandstones are seen dipping sharply to the westward. The range is therefore a sharp anticlinal, with perhaps a slip on the west. Following the ridge of the station southward, we find that it becomes eroded into a number of peaks with round summits, which end five miles south of the station, on the north side of a branch of the Bear, that rises in the range east of these peaks. On the east side of this creek we find the range continued in a ridge which is composed of Jurassic limestones representing the eastern members of the anticlinal fold. At the north end of the ridge is a peak which connects it with the range. Here the following were obtained:

Pentacrinus asteriscus,
Camptonectes bellistriatus,

which prove the Jurassic age of the layers. *Pentacrinus asteriscus* was also found at several other points in the ridge.

This ridge is about three miles in length, and ends against a branch of the creek which separates it from the main range. South of it is a collection of rather broad-topped hills, rising about 1,800 feet above the Bear, and in their strata dips to the westward were seen. It would therefore seem to be the western side of another anticlinal fold, for in Coketown Butte and east of it the dips are all to the eastward in the Jurassic rocks, while the butte itself shows the anticlinal in the Carboniferous limestones. At first I was inclined to consider the latter fold to be the same as that in the main range, but there are indications that the strike is a little east of north, which would carry the axis east of that shown at Station 38, and render it probable that this fold is the same as that of Station 41, which is 22 miles north on a branch of Thomas' Fork. The folds are sharper towards the south, and we have seen that the limestones in the centre of the anticlinal dip 80°, and that the coal-bed in the Laramie Group stands on end. In the region of Station 41 the greatest dips do not exceed 40°, and are generally only 25° or 30°, so that the folds have become much broader, and the older beds do not appear, the sandstones of the Laramie ? Group forming the surface rocks.

However, before it can be asserted that the folds are identical a section must be carried directly east from Station 38 to Smith's Fork. East of the station there is a high, somewhat-rounded hill, that is probably on the axis of the fold, and another similar one south of it appears to continue the line towards Coketown Butte. What the connection is between the Jurassic and the Laramie I am, in the absence of fossils from the intermediate beds, unable to determine positively, although I think the Cretaceous is present. The valley of Bear River between Smith's Fork and Thomas' Fork is comparatively narrow, widening out as we approach the latter stream. In two small hogback ridges on the west side of the Bear, below the mouth of Smith's Fork, the rocks show westward or northwestward dips. They probably represent a portion of the anticlinal of Coketown Butte.

THOMAS' FORK.

Thomas' Fork is a large and important branch of the Bear. It drains the country north of the Sublette Range as far as Crow and Beaver

Creeks (branches of Salt River), and also the country south and west of the southern end of the Preuss Range. This latter region was not visited, but was worked topographically from the surrounding high country. From sections made south and north of it, it has been considered as having the Jurassic as the surface formation, and it has been so colored on the map.

On the west side of Thomas' Fork, however, north of the Sublette Range, we have Station 41, located on a coarse, gray sandstone, which is conglomeritic in places, and dips to the westward at an angle of about 45°. Just east of the station the dip is to the eastward, so that the station is located on or near an anticlinal axis. This is, as I have said before, probably the fold of Coketown Butte. Following the axis to the north, the beds of the station are seen diverging as the elevation increases, so that when the divide to Beaver Creek is reached, underlying gray beds (probably Jurassic limestones) come to the surface and form the centre of the fold. At the point of a ridge, which is about a mile east of the station, the following fossils were obtained:

Unio vetustus.
Corbula pyriformis.
Corbicula (Veloritina) durkeei.
Pyrgulifera humerosa,
Goniobasis chrysaloidea.
Goniobasis cleburni.
Ostrea ——— ?

These prove the beds to be the Laramie Group, and equivalent to the Bear River Laramie.

Between the point where these fossils were found and the station there must be at least 3,000 feet of sandstones, in which occurs a band of black shales, like those of the section on the east side of Smith's Fork. East of the outcrop containing the fossils the principal outcrops show gray and greenish sandstones. If the conglomeritic sandstone of Station 41 is the same as the conglomerate (No. 6) of the section east of Smith's Fork, as I am disposed to think, then the coaly, black shales above are also identical, and these beds should, therefore, in all probability, be referred to the Cretaceous; but this division is made without any fossils having been found to warrant it. In an accompanying plate the section from Station 41 eastward is given.

West of the station another synclinal fold is seen, beyond which the gray Jurassic layers appear to outcrop in a bluff on the east side of the middle fork of Thomas' Fork.

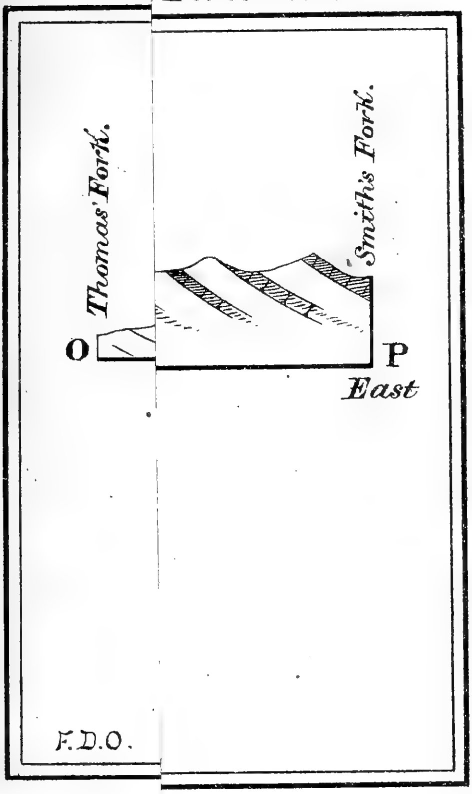
Thomas' Fork joins the Bear in a beautiful broad valley which is from two to four miles in width, and from the eastern side, the Sublette Range rises nearly 4,000 feet above it.

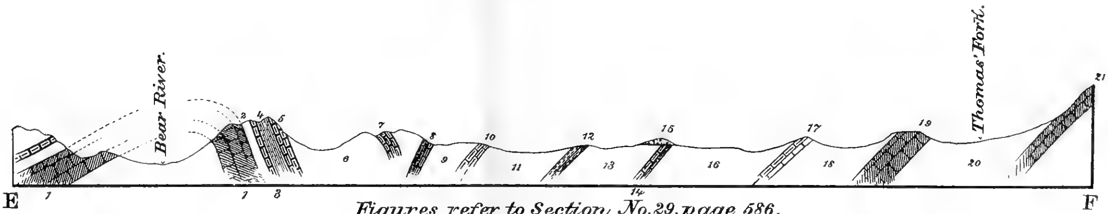
This valley is apparently a monoclinal in red sandstones. On the east side they rise inclining steeply from the range, and on the west they dip westward, outcropping in low bluffs. The folds that are found in the rocks west of Thomas' Fork will be noted under the head of Bear Lake Plateau.

BEAR LAKE PLATEAU.

Geologically the Bear Lake Plateau is the northern continuation of the Bear River Plateau of King's map (Atlas, Exploration of Fortieth Parallel). Topographically the latter ends west of the south end of Bear Lake, where the Wahsatch beds that form it are much more inclined, while on the east side the plateau is continued by the same

U. Plate LXIX.





Figures refer to Section No. 29, page 586.

Section from Bear River Eastward to Thomas' Fork.

F. D. O.

beds. Immediately south of the lake the older beds outcrop where the Wahsatch beds are removed, as I shall describe a little farther on. In 1871 Dr. Hayden crossed the plateau very nearly on our south line. He says:*

> After crossing Spring Creek, near Laketown, we enter a deep cañon with massive strata of limestone, inclining about northeast 50° to 70°. We have at the bottom first, very irregular-bedded, massive, cherty limestone, with no fossils; secondly, a yellow, calcareous sandstone of varied texture; thirdly, limestone in thin strata, very much warped or bent. * * * From the summit to Bear River Valley the variegated beds of the Wahsatch Group conceal all the older rocks.
>
> From the divide we descended the valley of Sage Creek to Bear River Valley. The Tertiary strata are nearly horizontal on either side. These rather modern beds partook of some of the later movements, and incline at angles from 1° to 10°.

Station 107 was located in the east side of the plateau about seven miles north of our south line. Gray conglomeritic sandstones outcrop on the station, and below them red and purplish sandstones, and below the latter light-greenish and white sands and marls. All these beds dip gently to the eastward from the station, seeming to pass beneath the alluvial deposits of Bear River Valley. West of the station the dip is to the west, but the beds soon become horizontal, rising again a little as we approach the western edge of the plateau near Station 108. North of Station 107 the westward dip in these beds becomes greater, and the eastern side of the fold has been considerably eroded, so that we find that instead of a plateau there is a ridge of hills, which have been named the Boundary Hills, from the fact that the western boundary line of Wyoming crosses them, following approximately their strike. Near the edge of Bear River Valley the Wahsatch beds show in the hills as far north as opposite the mouth of Smith's Fork. On the summit they extend much farther north, forming the capping of the ridge.

Station 108 is on the west side of the plateau, about six miles north of Station 107, and about eight miles farther west; Station 108 is on basalt, which has the appearance of being derived from a dike. There is no other remnant of basalt anywhere else on the plateau, nor, as far as seen, in the surrounding country south of Soda Springs, and this basalt is evidently not derived from the same source as that of Blackfoot Basin. It forms the capping to the station, which is a prominent hill, as seen from the surrounding country. On the maps published by the General Land Office it is named Mount Kimball, and this name has been adopted by us, as our plan has always been to use accepted names for mountains and peaks wherever we can find they have been named either by the settlers or previous explorers and surveyors.

Below the station the following section was made:

Section No. 26.

1. Basalt.
2. Coarse white sandstones.
3. Soft red sandstones with conglomeritic bands.

The entire thickness, including the basalt, is about 1,000 feet; 800 feet is probably the thickness of the Wahsatch beds here. They are all below the beds of Station 107. I was unable to get a section that gave me the entire thickness of the Wahsatch beds on the plateau. Below the beds of the section just given a coarse limestone outcrops, one layer of which is filled with remains of an indistinct *ostrea*, like *Ostrea strigulecula*. The dip of these limestones is eastward, and the outcrop is on the east side of a gully, which separates the Wahsatch beds from a

* Report U. S. Geolog. Survey for 1871–'72, pp. 157–158.

ridge that rises from the edge of the lake. In the latter the dip is to the westward, and the following beds were noted as forming the section:

Section No. 27.

1. Red sandstones.
2. Red and white quartzitic sandstones.
3. Pink quartzitic sandstones.

The last bed forms the western slope of the ridge that rises from the lake shore. The red sandstones of layer No. 1 are probably the same as those at the base of the section at Station 100, yet to be given, although it is possible that they are just below them, as the strike prolonged to the northward would fall a little east of Station 100. The ridges on the lake north of the station appear to curve somewhat, and probably show a swerving in the strike.

The finding of Jurassic fossils in beds dipping to the eastward indicates a possibility of an anticlinal fold west of Station 108. Looking north from the station, a fold is seen in the bluff on the north side of North Eden Creek. This fold is very distinctly shown in beds that lie below the red sandstones. This is probably the same fold through which the Bear flows east of Station 100, and across which a section has been made. At that point the western side of the anticlinal dips comparatively gently. Here, however, the western dip is steep, and at Station 100, also, the dip is rather steep, reaching 60°. As we go down, however, it decreases. If it is another fold, it must begin south of the Bear. North of North Eden Creek the Wahsatch beds rest uncomformably on the Jurassic and Triassic rocks for some distance north. They appear to be almost horizontal, and to have been deposited on the eroded surfaces of the upturned older rocks.

South of Bear Lake the Wahsatch beds have been removed, exposing the underlying Palæozoic rocks. On Station 110, east of Spring Creek, Mr. Mushbach obtained the following fossils:

Spirifer Rockymontanus.
Athyris subtilita.
Productus ——— ?
Zaphrentis ——— ?
Crinoidal fragments.

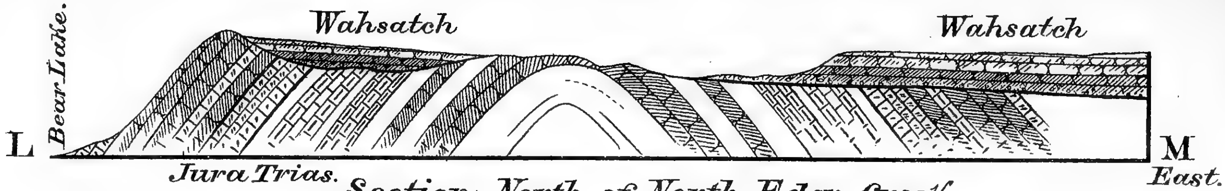
The limestones from which these were obtained dip to the eastward and represent the eastern portion of the anticlinal that lies west of Station 108, the overlying Red Beds of Jurassic limestones being eroded away. A short distance north of Station 110 the Wahsatch beds rest on these limestones, coming to the edge of the hill overlooking the south end of the lake. Station 109 is about three miles west of 110, and is on quartzites, whether of Carboniferous or Silurian age I am unable to say, no fossils having been obtained from them or nearer to them than Station 110.

Returning to the northern portion of the plateau, we find it limited by the cañon of Bear River, which crosses with a most eccentric course, best shown on the accompanying map.

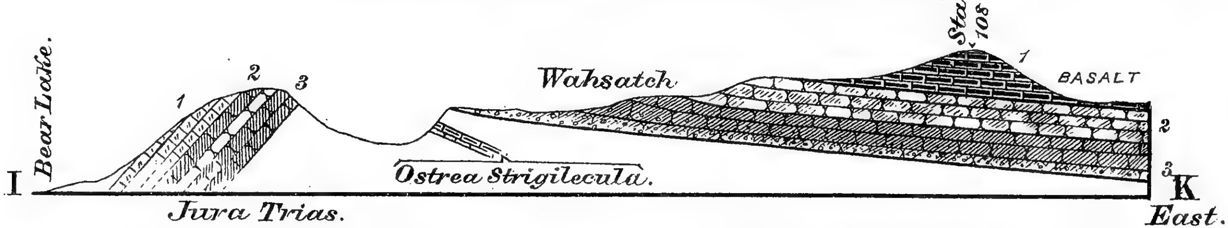
The following is the section from Station 100 west to the ridge that slopes to the edge of the lake:

Section No. 28, *west from Station* 100.

Base.	Thickness in feet.
1. Red sandstones	?
2. Red sandstones, somewhat lighter in color than No. 1	200
3. White quartzites	



Section North of North Eden Creek.



Section No. 27 page 584. Section No 26 page 583.

Sections on Bear Lake Plateau.

F.D.O.

Base.	Thickness in feet.
4. Red sandstones, with interlaminated brick-red shales	66
5. Purplish limestones	
6. Space covered by a red *debris*, over which bowlders of white quartzite are scattered. The angle of dip in the beds up to this point is 40° to southwest. The strike of the beds is north 2° west	200
7. Dull purplish-red, coarse sandstones, with about 15 feet of light-colored siliceous sandstone at the base	
8. Space in which beds are covered	35
9. Coarse, yellowish sandstone	
10. Space covered (probably sandstones)	100
11. White limestone, shaly at the base, and having a yellow band near the top. The strike is north 7° east; dip, 60° to the northwest	40
12. Space in which beds are covered by a reddish *débris*, among which fragments of limestone are found	540
13. Gray limestones, with indistinct fossils, among which the following have been identified: *Eumicrotis curta*, *Aviculopecten idahoensis*	90
14. Bluish-gray limestones, with bands of sandstone. The limestones are fossiliferous, containing the same fossils that are found in layer No. 13	80
15. Gray-blue limestones like No. 14. The strike is north 9° east; dip, 60° to the northwest	150
16. Space in which the beds, which are covered, are probably limestones and shales, as indicated by a few obscure outcrops	490
17. Laminated limestone in thin bands, with shaly layers covered in many places with a yellowish *débris*	180
18. Space in which the beds are concealed	70
19. Bluish and white limestones, containing traces of fossils like those in layers Nos. 13 and 14	50
20. Covered space, probably underlaid with limestones	680
21. Limestones and shales	
22. Space in which the beds are concealed	
23. Blue limestones	
24. White quartzite, dipping 35° north of west	
25. Space underlaid by quartzites?	
26. White limestones, weathering very white and pink on exposed surfaces	
Total	2 981

On layer No. 26 a location was made. Looking south from this point, the ridges into which the beds have weathered appear to run out under Bear Lake.

Station 101 is located $3\frac{1}{2}$ miles north of Station 100, and is on red sandstones. Between the stations there appears to be a deflection to the eastward in the strike of the sandstones.

As we have seen, all the beds in the section have dips to the northwest. The beds, therefore, must be a portion at least of the western side of the anticlinal, the axis of which is seen in that portion of the cañon of Bear River where the river is flowing almost due north.

On the north side of the Bear, about due north of Station 101, there is an outcrop of quartzitic sandstones and blue limestones, dipping north 63° west at an angle of 30°. Below these beds the red sandstones outcrop at the point where the cañon begins at one of our sub-stations, and between are limestones and limestone shales.

The sub-station (*a*) is on a point opposite where the Bear bends from its northern course to a northwest course. At this bend a stream comes in from the north, occupying the axis of the anticlinal in which the Bear lies to the south. The valley is continuous, and has beautiful meadows, which have been only partially taken up by settlers. On the west side of this valley is a rather prominent ridge, on the south end of which another sub-station (*b*) was located. This station is on red sandstones, which dip south of east about 70°. Toward the north this dip must be more to the south, as indicated by the dips observed farther down the Bear on the west side of the anticlinal. Still farther to the north the

topography indicates that the strike curves to the westward, and continues the fold northward into the Preuss Range.

Above the red sandstones is the following section, running eastward to Thomas' Fork, the figures corresponding with those in the accompanying plate:

Section No. 29, from Bear River eastward to Thomas' Fork.

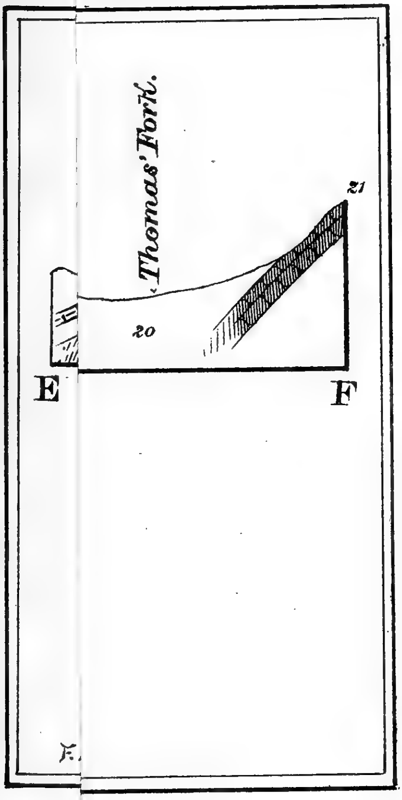
1. Red quartzitic sandstone, dip 70° to southeast.
2. Laminated limestones.
3. Blue limestones.
4. Limestone shales.
5. Blue limestones, with fragments of an indistinct *ostrea*, probably *O. strigulecula*, dip 60° to southeast.
6. Valley in which beds are concealed.
7. Blue limestones dipping southeast rather steeply.
8. Limestones like No. 7, almost vertical, but dipping northwest. There is some crushing of the beds here, but time did not permit close investigation of the sharp fold.
9. Covered space.
10. Limestones dipping northwest about 45°.
11. Valley covered with *débris* of limestones.
12. Arenaceous and calcareous shales.
13. Space with covered beds.
14. Laminated blue limestones, dip northwest.
15. Conglomerate with arenaceous matrix, containing rounded fragments of quartzite and limestone. This conglomerate rests horizontally and unconformably on the limestones of layer No. 14.
16. Covered space.
17. Limestones.
18. Space.
19. Red sandstones.
20. Valley of Thomas' Fork.
21. Red sandstones, rising high on the slopes of the Sublette Range, standing almost vertical, dipping to the westward or northwest.

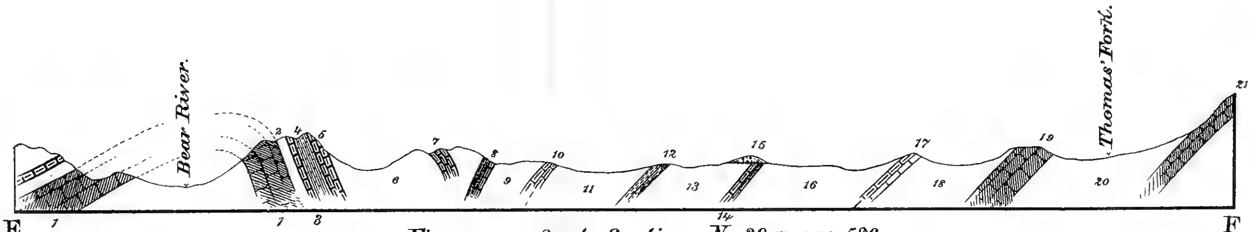
The red sandstones of No. 19 are probably the same as those of Station *b*, and also those outcropping across the Bear, west of the station. The station is on the sharp side of the anticlinal, the beds on the west side dipping comparatively gently to the west. The distance between this point and Station 100, which is also on Red Beds, seems too great for the Red Beds of both points to be the same fold; so that there is probably another fold which begins between the two points and continues southward toward Station 108, which we have already described.

From layer No. 8 to the end of the section just given we find the limestones, &c. (layers 10, 12, 14, 17, and 19), outcropping in low ridges so obscurely that the angle of dip could not be determined. There is scarcely any doubt of their Jurassic age, judging from the few fossils seen and their position in relation to the Red Beds. As to the conglomerate, layer No. 15, I am inclined to consider it of Pliocene age (the same as similar beds in Bear Lake Valley, yet to be described), as they do not resemble the Wahsatch beds on the plateau, which are also at a much higher level. However, nothing was seen by us upon which any more definite statement as to the age of the beds could be based. What was seen was a mere fragment, but it indicated that this region has been covered by a lake, and the probability is that the lake existed in late Tertiary, or possibly in Quaternary time.

The Bear Lake Plateau therefore consists of an irregularly-eroded surface of the Wahsatch conglomerates and sandstones which rest upon the upturned and eroded edges of Paleozoic rocks; the latter for the most part of Jurassic and Triassic (?) age. Toward the north the folds observed in the uncovered portions of these beds show that before the deposition of the Wahsatch Group the older rocks were subjected to

Plate LXXI.





Figures refer to Section No. 29, page 586.

Section from Bear River Eastward to Thomas' Fork.

F. D. Q.

considerable upheaval and compression resulting in the formation of a series of folds with northeast and southwest axes. Following this folding was a period of erosion when the beds were probably above the sea level. Subsequently they formed a portion of the bottom of the early Tertiary lake, to be again uplifted and eroded late in Tertiary time. The Wahsatch beds show, as we have seen, a slight synclinal on the plateau, and west of it, along the east edge of the Bear River Range, south of Bear Lake, they are quite sharply upturned. Following the erosion of the Wahsatch, we find evidences of another lake, which was probably quite local.

BEAR LAKE VALLEY.

From the cañon at the north end of the Bear Lake Plateau the river comes out into a broad valley, which is evidently an old lake basin. It is now occupied, at this point, by a marsh which, at certain seasons, becomes a lake. In this marsh Bear River loses its character as a stream, and emerges again at the north end of the marsh. South of the marsh is Bear Lake. It occupies the depression between the Bear Lake Plateau and the Bear River Range. It is evident that the existing lake is but the remnant of one that was much larger. The view of the lake from the Bear Lake Plateau is beautiful; the water has an exquisite blue tint, which is equalled by few bodies of water in any part of the world. The shape of the lake is somewhat peculiar, both the north and south ends being almost square-cornered. The length is 19 miles, and the greatest width 8 miles. The average width of the main body is about 6 miles. Toward the south it narrows to 4 miles. The shape of the lake is best appreciated by reference to the map. The depth of the lake, as given in the report of 1871 (p. 156), is 175 feet at the deepest portion, with an estimated average depth of 40 to 60 feet. The lower portion of the lake is in Utah and the upper portion in Idaho, the line crossing it a little north of the mouth of Swan Creek.

The marsh north of the lake is separated from it by a very narrow, beautifully curved bar, which is only slightly raised above the level of the water. This marsh is partially lake, near the main lake, and at some seasons must be a real lake of considerable extent. This fact has led to confusion on some maps which give two lakes. When we were there, in August, the lower body was almost entirely a marsh.

There are numerous towns in the valley. At the south end of the lake Lake Town and Meadowville are two flourishing villages, with populations of a little over 100 each. On the west side are the following towns: Swan Creek, Fish Haven, Saint Charles, Bloomington, Paris, Ovid, and Liberty. Below the marsh, on Bear River, the towns are Montpelier, Bennington, and Georgetown. The entire population of the valley is about 1,500.

On the east side of the lake there is a very limited area of cultivable land on which there are several small settlements.

The soil of Bear Lake Valley is fertile and well watered, but the winters are severe, and late and early frosts are frequent. The elevation of the lake is 5,943 feet. Wheat of good quality is raised. The geology of the eastern side of the lake has been given under the head of the Bear Lake plateau. South of the lake there is a broad valley covered with Quaternary deposits, which represent an area of good agricultural land. In the hills Carboniferous limestones and quartzites outcrop from beneath the Wahsatch beds. The latter rise on the western flank of the Bear River Range. The southwest side of the lake was not visited by me, but from the notes of Mr. Mushbach it is evident that the Wahsatch

Group is not seen north of Swan Creek. On the west side of the southern extremity of the lake, Mr. Mushbach made two stations on a small hog-back-like ridge, in which a conglomeritic quartzite outcrops with eastern dips. Near the mouth of Swan Creek similar quartzites were seen by him, with eastern dips, while in the range to the westward the dip is to the west. There is here, therefore, an anticlinal, the northern extension of an anticlinal that lies beneath the Bear River plateau, or perhaps the eastern portion of the very broad anticlinal that lies west of it, as shown on the maps of the Fortieth Parallel Survey. The latter fold, however, probably becomes narrower as it extends to the north.

This anticlinal near Swan Creek is the same one referred to by Dr. Hayden in the report for 1871 (p. 157), when he says: "The beds of quartzite incline like a steep roof from the west side of the mountain, forming a wall very near the road. The inclination of the quartzites was 60°, while all along the sides of the mountains the basset ridges of the strata are shown inclining in an opposite direction 10° to 15°." The lake is probably underlaid by at least one anticlinal fold. We have seen that the ridges south of Station 100 run out under the lake. Quartzites are the prevailing rocks in the foothills on the west side of the lake, and they come down close to the lake, forming rounded ridges, between which there are numerous rapid and clear streams.

From the north end of the lake the valley on the west side widens, and west of the marsh it is from two to three miles to the edge of the hills. Northwest of the town of Paris outcrops of white beds are seen on the lower hills. Station 115 was also located on similar hills in which white limestones and sandstones outcrop. Remnants of similar beds are also seen on the hills to the westward of the station. They are so like the beds seen in various portions of Cache Valley that they have been colored as representing the same formation, viz, Pliocene Tertiary. Back of Montpelier, on the east side of the valley, limestones are seen with a dip to the westward. They come up over the ridge and are probably of Jurassic age. A little farther south an outcrop of white sandstone was noted, probably Pliocene? The valley here is very broad and covered with a local drift. This drift extends along the valley of the Bear as far as Soda Springs. The Pliocene beds are probably present on both sides of the valley as far as Twin Creek. The latter stream drains the western slopes of the Preuss Range. It has a broad meadow-like valley, in which Georgetown is located. The southwest spurs of the Preuss Range are probably composed of Jurassic rocks, although the Carboniferous may show in some of the deeper gorges. Back of Bennington Dr. Hayden made the following section in 1871: *

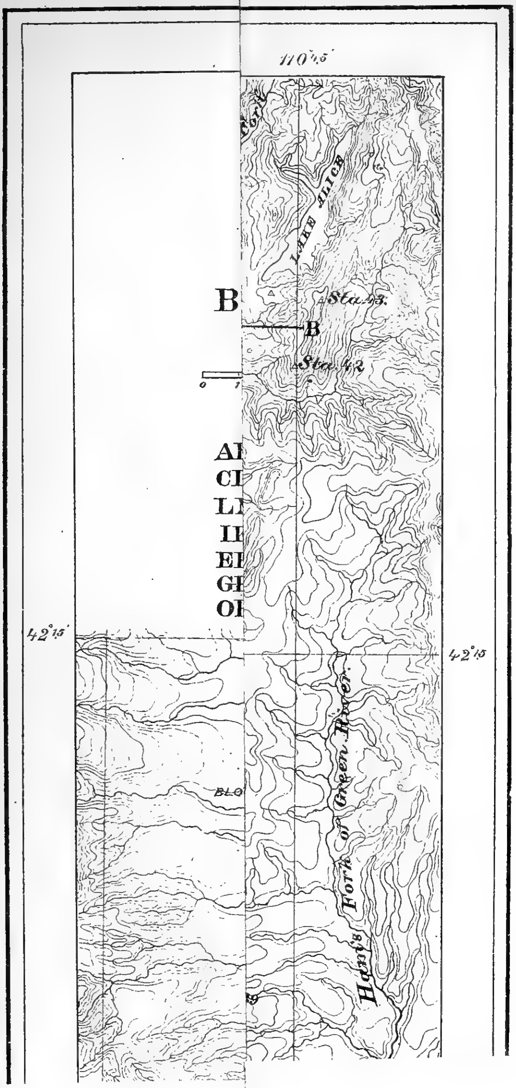
Top.	Feet.
1. Massive yellowish-gray, hard, and quite pure limestone	200
2. Hard, tough, bluish or steel gray, calcareous mud, with all the peculiar markings of a shallow mud-deposit, in layers from an inch to two feet in thickness and very regular	300
Total	500

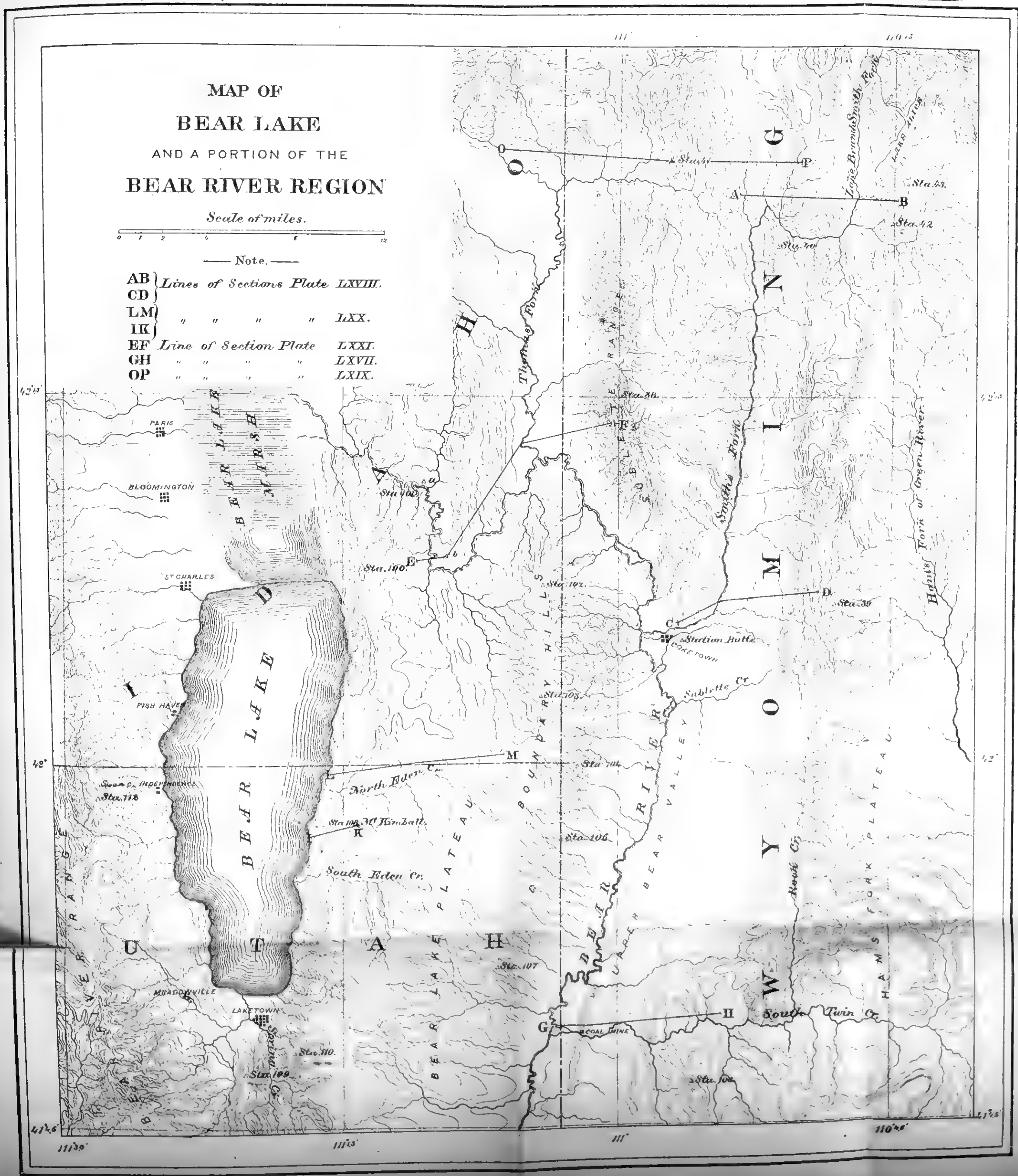
I think there is very little doubt of the Jurassic age of these beds, as they appear to correspond closely to the beds observed in the Aspen Ridge, which continues the folds to the northwest.

Just north of Georgetown there are several buttes in which white sandstones and conglomerates outcrop. These I have referred to the Pliocene. The valley of Bear River between Georgetown and Soda Springs was not passed over by me, but there is no doubt as to its being

* Report U. S. Geol. Survey for 1871, 1872, p. 155.

U.S. Geolo Plate LXXII.




MAP OF
BEAR LAKE
AND A PORTION OF THE
BEAR RIVER REGION
Scale of miles.
0 1 2 4 8 12
Note.
AB } Lines of Sections Plate LXVIII.
CD }
LM } " " " " LXX.
IK }
EF Line of Section Plate LXXI.
GH " " " " LXVII.
OP " " " " LXIX.
IDAHO
UTAH
WYOMING
BEAR LAKE
BEAR LAKE MARSH
BEAR RIVER
UPPER BEAR VALLEY
BEAR LAKE PLATEAU
BOUNDARY HILLS
SUBLETTE RANGE
HAMS FORK PLATEAU
BEAR RIVER RANGE
PARIS
BLOOMINGTON
ST CHARLES
FISH HAVEN
INDEPENDENCE
MEADOWVILLE
LAKETOWN
COKETOWN
COAL MINE
Thomas Fork
Smith's Fork
Lone Branch Smith Fork
Hams Fork of Green River
Sublette Cr.
North Eden Cr.
South Eden Cr.
Rock Cr.
South Twin Cr.
Station Butte
Mt. Kimball
Sta. 38
Sta. 39
Sta. 40
Sta. 41
Sta. 42
Sta. 43
Sta. 100
Sta. 101
Sta. 102
Sta. 103
Sta. 104
Sta. 105
Sta. 106
Sta. 107
Sta. 108
Sta. 109
Sta. 110
Sta. 118
111°
110°45'
111°15'
111°30'
42°15'
42°
41°45'

occupied by lake deposits. This valley was described by Dr. Hayden in 1871, and I quote from his report:*

About three miles above Soda Springs, on the margin of Bear River, there is a bed of black slaty clay underneath the superficial deposits of drift, which contains a seam of impure coal, visible only when the water is low in autumn. The slate above the coal is literally crowded with fresh-water shells, as Planorbis, &c.

A little farther up the river, on the opposite side there are hills, cut by the river, showing about 200 feet of gray indurated sandstones, with beds of pudding-stones and light gray and whitish marly sand and clay, a very modern deposit, but attaining such a thickness and giving form to the high hills bordering the river, as to be regarded as worthy of attention in describing the geological features of this valley. I may state, in short, that for 10 miles the valley and the foothills on either side exhibit an extensive deposit, gradually passing up into the Quaternary or drift, and over the drift is here and there a crust of basalt. There are also old spring deposits in the form of rather compact tufa.

About fifteen miles above Soda Springs the river cuts through a vast thickness of thin shales, varying in thickness from one-twentieth of an inch to an inch, averaging about one-eighth of an inch, thick, resembling the Green River shales on the Union Pacific Railroad. They are mostly horizontal, but occasionally incline 3° to 5°. They reach a thickness of 500 to 800 feet and appear to pass up into variegated beds of light gray and pink sands and clays in this valley, resembling those of the Wahsatch Group west of Fort Bridger.

The appearance of the large mass of shales in the valley of Bear River is not easily accounted for, and they do not appear to conform to the older rocks. No fossils could be found in the shales, and all I can say of them is that they appear to be of Modern Tertiary age, and that in the scooping out of the valley they seem to have escaped the general erosion.

These beds last described are probably of Pliocene age and equivalent to those of Cache Valley and the Malade Valley. What their extent is on the west side of the river I am unable to say. They probably extend northward from Station 115, forming the lower hills west of the river, but north of Georgetown, I have no data as to their limit westward. I have therefore colored them only as bordering the valley along the foot-hills of the Bear River Range.

The coaly layer noted three miles above Soda Springs is probably of the same age as a bed noted in Gentile Valley, with which *Planorbis*, *Sphærium*, *Limnæa*, and other fresh-water forms were associated. The beds in the latter case passed under the basalt, as do those near Soda Springs. It is altogether probable, therefore, that the lake of Gentile Valley and Basalt Valley connected by a narrow inlet with the lake that filled the Bear Lake Valley and the valley of Bear River, north of it.

We can, therefore, with considerable accuracy state that the Bear River Valley is a basin of at least three lakes. First, the Pliocene Tertiary Lake; second, the lake (probably Early Quaternary) which deposited the coaly strata; and thirdly, the late Quaternary Lake, of which a remnant still exists in Bear Lake and Bear Marsh. Whether the lake was continuous from Pliocene time is difficult to say, but it probably was not. At the end of the Pliocene deposition there must have been orographical disturbance, as we note dips in the strata at all localities where the beds have been seen. These dips at some places, as in Bear Lake Valley, are only a few degrees, but in others they were as high as 60°. This subject will be referred to again in the *résumé* of the formations.

PREUSS RANGE.

The main portion of the Preuss Range was described in the preceding chapter under the head of the Blackfoot River, which drains the greater portion of the mountains. The southern spurs, however, form the east side of the Bear Lake Valley, and the Aspen Ridge is the boundary

*Report U. S. Geol. Survey, 1871, 1872, pp. 154, 155.

of the Bear River Valley on the east side from Georgetown to Soda Springs. Mount Preuss is the culminating point in the range and attains an elevation of 9,979 feet. To the southward the range soon falls off and the Jurassic limestones curve over the ridges in a series of folds, probably not more than two in number. This region was not crossed, and we have, therefore, no geological data to present in regard to it.

The slopes of the range are well timbered, and give the settlers in the valley a good source of supply for pine wood. The principal streams draining the southern portion of the range are Twin Creek and Tullock's Fork, or Davis' Creek. The latter in reality drains the ridges just south of the range. Between the two creeks are several streams, which in the spring furnish water for irrigation. Late in the summer most of them are without water.

The nucleus of the range, as we have already noted, is Carboniferous, the limestones being very sharply folded towards the north. Jurassic limestones and sandstones, with beds of quartzite, are, however, the prevailing rocks. Their southern prolongations were crossed in the cañon of Bear River north of the Bear Lake Plateau.

The section of the beds at the latter point has already been given, and the sections north of Mount Preuss will be found in the preceding chapter.

SODA SPRINGS AND BEAR RIVER BEND.

The soda springs at the bend of Bear River have long been known, as the old Emigrant Road passes by them. On account of the effervescing gas and pleasant pungent taste of the water in some of the springs, they were known as the Beer Springs. Most of the springs are cold, only one or two properly deserving the name of thermal springs. The principal one is the one named the Steamboat Spring by Frémont.

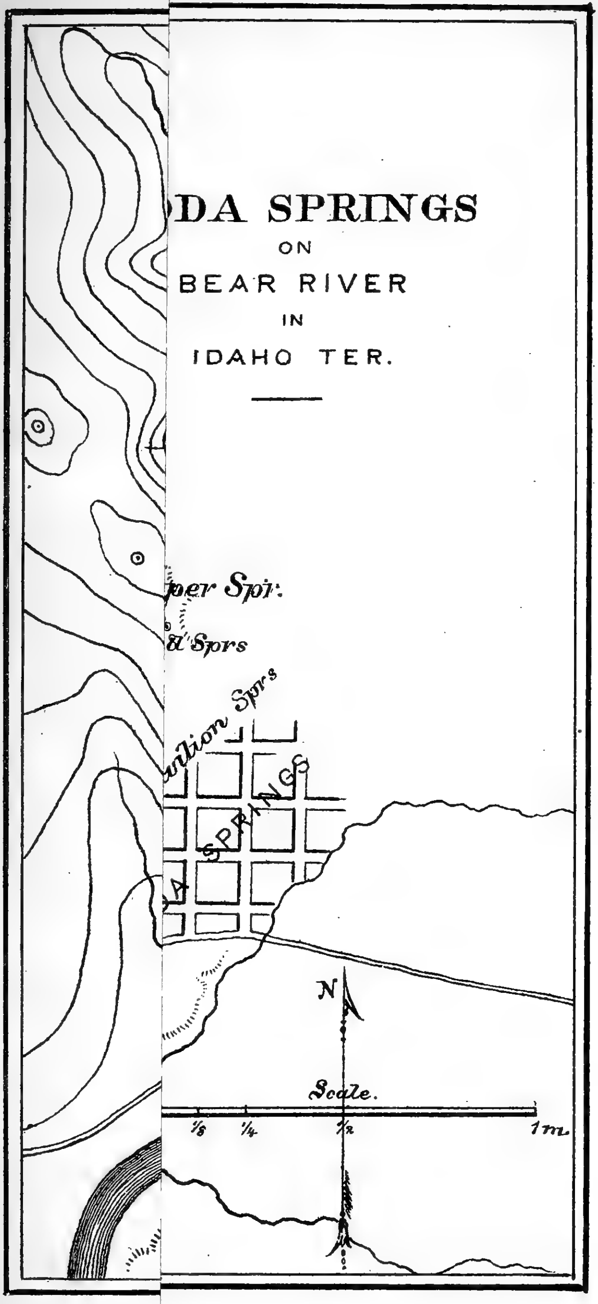
Steamboat Spring.—This spring is on the bank of the river, near the edge of the water. It has a small cone about two feet in diameter, rising several inches above the surrounding level. The opening is coated with a bright red deposit of iron. There is a large escape of carbonic acid gas, which agitates the water so violently that it appears to be boiling. It is thrown about two feet at the highest, although this is only at intervals. It is accompanied by a subterranean noise, from which fact it was named. The deposit is hard and almost like porcelain. An analysis is given in Frémont's Report,* which is quoted below.

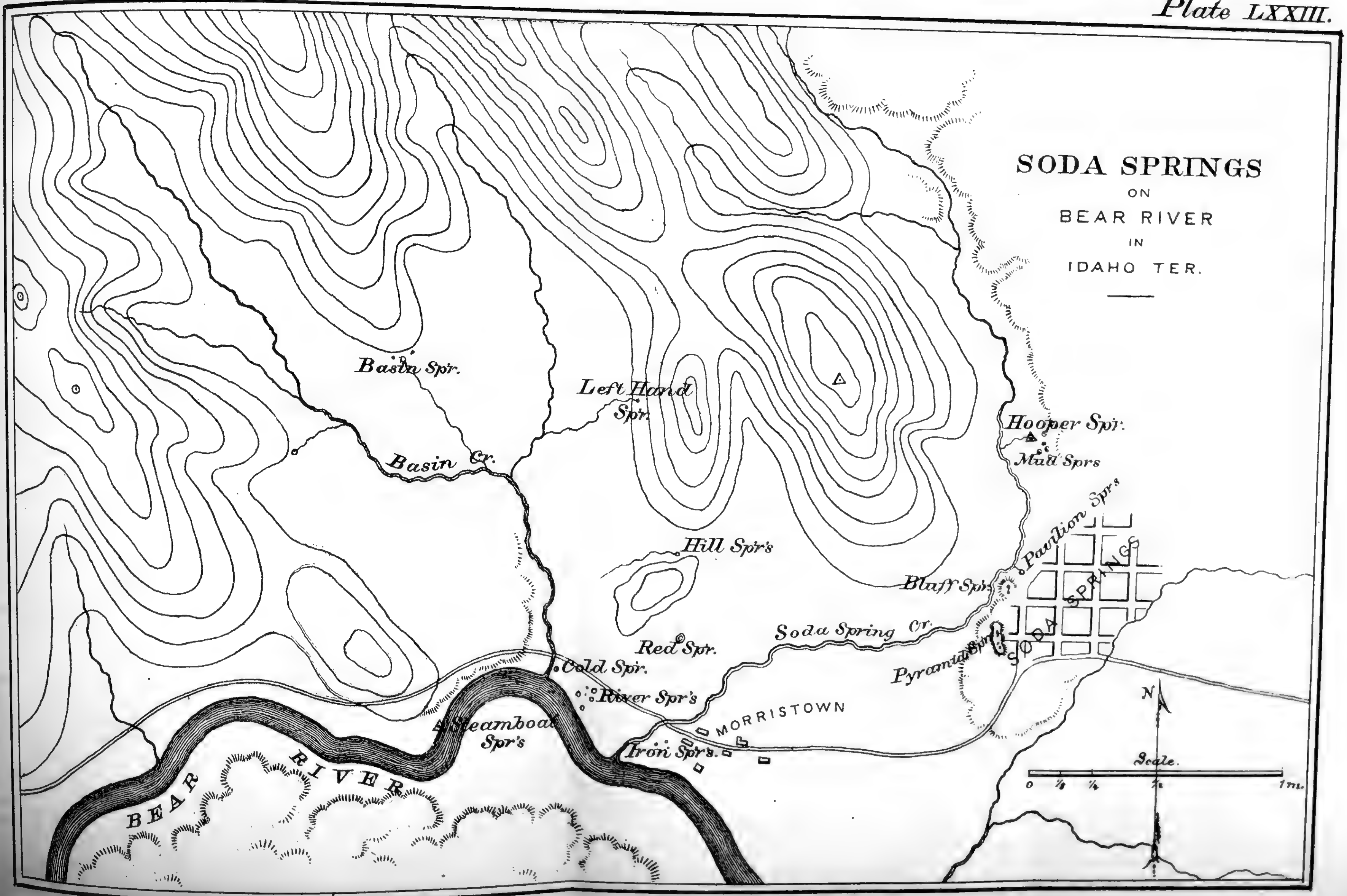
Analysis.

Carbonate of lime	92.55
Carbonate of magnesia	0.42
Oxide of iron	1.05
Silica, Alumina, Water and loss	5.98
	100.00

The water is not very agreeable in taste. It is slightly sharp, with a metallic and sweetish taste. Its temperature at 1.30 p. m., when the air was at 80° F., was 88° F. The following day it was $87\frac{3}{4}$° F. In 1871, the temperature was given as $85\frac{1}{2}$° F. The difference is probably due to a difference in thermometers, the temperature given by Frémont is 87°, showing that there has been but little or no change in the temperature. There is a very slight overflow of water. Near this spring

*Frémont's First and Second Expeditions, 1842–'43 and '44.


DA SPRINGS
ON
BEAR RIVER
IN
IDAHO TER.
per Spr.
a Sprs
milion Sprs
A SPRINGS
N
Scale.
1/8
1/4
1/2
1m.


SODA SPRINGS
ON
BEAR RIVER
IN
IDAHO TER.
Basin Spr.
Left Hand Spr.
Basin Cr.
Hooper Spr.
Mud Sprs
Pavilion Sprs
Hill Spr's
Bluff Spr.
Soda Spring Cr.
SODA SPRINGS
Red Spr.
Cold Spr.
Pyramid Spr.
River Spr's
Steamboat Spr's
MORRISTOWN
Iron Spr's.
BEAR RIVER
N
Scale.
0
1m.

are two small vents, from which hot air and gas escape. The temperatures here were 83° F. and 85° F. There is a great deal of old deposit surrounding these springs, and the remnants of spring basins, in which the springs have long been extinct, are seen in many places. On the opposite side of the Bear several reddish and yellowish cones or chimneys are still standing.

A small bluff just above the Steamboat Spring has a curious bright-yellow tufa, with a coral-like structure, which has been deposited by springs in times long past. It is calcareous, colored with iron. The whole bank of the river for some distance is made up of tufa. Even some distance back from the river there is but little soil, the hard tufa forming most of the surface, covered in many places with a saline efflorescence.

Above the mound of yellow tufa, a creek comes in, which we will call Basin Creek, as the large spring at the head of it was called Basin Spring by Frémont.

Basin Creek.—Near the mouth, in a gully about 300 yards from the Steamboat Spring, is a spring about three feet in diameter. There is no iron deposit; and the water has a sharp, sweetish taste, with a slight escape of carbonic-acid gas. Its temperature was 50° F., with the air at 79° F. This spring I have named *Cold Spring.* Near it is a small hole, from which gas escapes through the water with considerable noise.

Near the head of the creek there are several springs, some of which are ordinary cold springs. The largest spring is *Basin Spring.* This spring was not visited by us this year. The following description was given in the Report for 1871 (p. 152) by Dr. Hayden:

Near the foot of the hills, a mile from the river, there is a soda spring, with a mound about 10 feet high, with a large rim 30 by 100 feet, but with a small quantity of water compared with what formerly flowed from it; temperature, 53½°. Near this spring are a number of large springs issuing from beneath the hills of limestone, without the deposit or the taste of the acidulous ones, so that we have in close proximity, and apparently coming from the same rock, with about the same temperature, acidulous and non-acidulous springs. There were two springs the waters of which were above the ordinary temperature, respectively, 76½° and 78°.

This spring is without doubt the same one described as follows by Fremont:*

Descending the mountains and returning towards the camp along the base of the ridge which skirts the plain, I found at the foot of a mountain spur, and issuing from a compact rock of a dark blue color, a great number of springs having the same pungent and disagreeably metallic taste already mentioned, the water of which was collected into a very remarkable basin, whose singularity perhaps made it appear to me very beautiful. It is large—perhaps 50 yards in circumference—and in it the water is contained at an elevation of several feet above the surrounding ground by a wall of calcareous *tufa*, composed principally of the remains of mosses, three or four, and sometimes ten feet high. The water within is very clear and pure, and three or four feet deep, where it could be conveniently measured near the wall; and at a considerably lower level is another pond or basin of very clear water, and apparently of considerable depth, from the bottom of which the gas was escaping in bubbling columns at many places. This water was collected into a small stream, which in a few hundred yards sank under ground, reappearing among the rocks between the two great springs near the river, which it entered by a little fall.

On the eastern branches of Basin Creek there are several springs, in which the water is cold and of agreeable taste. In 1871 some of these were named and temperatures taken as follows:

Hill Springs, 56½° F., 58° F., 53½° F.—These are situated at the end of a ridge northwest of the west village.

Left-Hand Springs, 54½° F., 52½° F.—These are northwest of the Beer Springs.

Beer Springs.—The Beer Springs, as named by Frémont, are on the

* Fremont's First and Second Expeditions, 1842–'43–'44, p. 138.

north side of the road on the west side of Soda Spring Creek. He says:

They are very numerous and half hidden by tufts of grass. * * * They are some of them deep and of various sizes, sometimes several yards in diameter, and kept in constant motion by columns of escaping gas. By analysis, one quart of the water contains as follows:

	Grains.
Sulphate of magnesia	12.10
Sulphate of lime	2.12
Carbonate of lime	3.86
Carbonate of magnesia	3.22
Chloride of calcium	1.33
Chloride of magnesium	1.12
Chloride of sodium	2.24
Vegetable extractive matter, &c	0.85
	26.84

The carbonic acid originally contained in the water had mainly escaped before it was subjected to analysis, and it was not, therefore, taken into consideration.

I am unable to identify his large Beer Spring in which the temperatures obtained by him were 65° and 56°. North of the road, however, there is a red mound in which the springs are extinct, but I think this is too far from the river to be the locality of the springs mentioned by him.

River Springs.—This name I have given to a couple of springs near the river, between Basin Creek and Soda Spring Creek. They are about 25 yards above Cold Spring, and gave the following temperatures with the air at 80° F.: Spring No. 1, 71° F.; spring No. 2, 59° F. These I believe to be the springs put down on the map made in 1871* with temperatures of 65° and 66½°, as they are surrounded with extinct basins or holes and occupy the same relative position. In the river opposite these springs there are many points of ebullition, showing the presence of springs in its bed, which has a layer of tufa at the bottom.

Iron Springs.—Two of the most agreeable tasting springs are situated near the mouth of Soda Spring Creek, on the east side, near the west village.

Spring No. 1 has a slight ebullition of carbonic-acid gas; its temperaature was 54° F., with the air at 78° F.

Spring No. 2 is quiet, but the water is very pungent; the basin is bright red in color; the temperature was 60° F., air 78° F.

The town of Soda Springs is on Soda Spring Creek, about a mile and a half from the west village, which formerly was called Morristown. Near it there are several important springs. One of these is called the Pavilion Spring.

Pavilion Spring.—It has been walled up and a pavilion erected; it is close to the creek and is rather agreeable in taste; considerable gas escapes, and the basin is lined with iron oxide; the temperature was 52° F., with the air at 82° F. In the creek opposite the spring there are several points from which gas escapes through the water, and above the Pavilion there are several small springs. What will attract notice first here, however, are the cone-like mounds west of the town. These, in 1871, were called Pyramid Springs and Bluff Springs, and I shall retain the names in the description.

Pyramid Springs.—The mound on which these springs are located has been built layer by layer from the sediment left by the evaporation of the water as it has poured over the sides from the springs. There is a spring on the summit from which water is run into a tank to supply

*Report U. S. Geol. Survey for 1872, 1873, p. 173.

Thos. Sinclair & Son, Lith.

FORMATION SPRING AT SODA SPRINGS.

bath-houses. The channel conveying the water is coated with iron oxide. Very little gas escapes from the spring. Below the summit there are two springs; one of them is about two feet in diameter and gives off considerable gas. There are besides several small holes, in which the water is, for the most part, perfectly quiet. The temperatures were the same in all the springs, viz, 80°, with the air at 74°.

At the south end of the mound there are springs in which the following temperatures were noted: No. 1, 81° F.; No. 2, 80° F.; with the air at 85°. There are also several small places from which water trickles. These springs are all exposed to the direct rays of the sun.

Bluff Spring.—This spring is situated on a mound similar to the one just described. The water has been used for bathing purposes, but the bath-houses have been destroyed. There are two principal springs, with temperatures of 78°. There are also a number of small holes from which water trickles.

These springs are the ones described by Frémont as the Fountain Springs. He says: "At a former time, when these dried-up fountains were all in motion, they must have made a beautiful display on a grand scale; and nearly all this basin appears to me to have been formed under their action, and should be called the place of fountains."

Frémont, however, did not see the Hooper Spring nor the Formation Springs.

Hooper Spring.—This spring is the best spring of the entire group. It is on Soda Spring Creek, nearly 4 miles above its mouth and about 1½ miles above the town. It is close to the edge of the stream and is square, measuring 10 feet 9½ inches by 10 feet 9½ inches. It has probably been artificially enlarged. There are five points of very active ebullition, caused by the escape of carbonic acid gas, which gives the water an extremely agreeable taste. The basin is lined with a deposit of iron oxide. The temperature was 53°, while the air was 78°. Close to the spring there are a number of muddy pools and springs surrounded with turf. The water in them is below the general surface and the openings are generally smaller than the springs beneath. Carbonic-acid gas escapes in great quantity, as we soon appreciate when we stoop to look into the springs. Some of the holes contained dead frogs that looked as though they were still alive. Other holes contained blackbirds that had been suffocated by the gas escaping from the concealed springs.

Formation Springs.—About four miles above the mouth of the creek and two miles east of the Hooper Spring, on the east side of the valley, is a collection of basins of old springs formed of calcareous tufa. There is at present but little water. The place is called Formation or Petrifying Springs. There is an area of perhaps a half a square mile, which is covered with semicircular basins of coarse tufa. Some are six feet in depth and of various sizes. These basins are empty. The partitions are several feet in thickness and lined with stalactitic and other tufaceous ornamentation. In some there are huge masses that have been formed by the coating of plants, in which the form of the leaf and twig are perfectly retained. The water holding the carbonate of lime in solution has poured over the plants, and, evaporating, has coated them so as to bind them into one mass. This process is seen at all calcareous springs, and at the bath-houses in the village wire baskets are coated by allowing the water to flow over them and evaporate. The basins of the Formation Springs are much like the basins at Gardiner's River, in the Yellowstone National Park, but the deposit is evidently much older, and instead of the gray tint that the latter acquires with age this has a yellow tint. The tufa is quite hard, and specimens of it are frequently

seen for sale on the Union Pacific Railroad. There is but little doubt that these springs will become one of the pleasure resorts of Idaho. In 1877 about thirty people, mostly from Salt Lake, Utah, had visited them. There is no hotel, and the accommodations are limited, but the beautiful valley and the picturesque scenery of the surrounding hills must eventually attract attention from tourists. There is game in the mountains and the streams abound in trout.

In the following table I present the observations of last year in comparison with those made in former years:

Name of spring.	Observations in 1877.			Observations in 1871 by United States Geological Survey.			Observations in 1843 by Frémont.		
	Temperature of spring, Fahrenheit.	Temperature of air, Fahrenheit.	Time of observation.	Temperature of spring, Fahrenheit.	Temperature of air, Fahrenheit.	Time of observation.	Temperature of spring.	Temperature of air.	Time of observation.
Steamboat Spring	° 88 87¾	° 80 79 *80½	1.30 p. m. 11 a. m.	° 85½	°		° 87	° 28.5	A. M.
Steam holes at Steamboat Spring.	83 85	80	1.30 p. m.				81.5	28.5	A. M.
Cold Spring	50	79	A. M.						
Basin Springs 1 2 3				53½ 76½ 78					
Hill Springs 1 2 3				56½ 58 53½					
Left Hand Springs 1 2				54½ 52½					
Beer Spring (†)							65 56	62.5 28.5	Sunset. Sunrise.
River Springs 1 2	71 59	80 80	P. M	‡65 66½					
Iron Springs 1 2	54 60	78 78	10½ a. m. 10½ a. m.						
Pyramid Springs 1	80	74	9½ a. m.	74 72½ 71½ 71½		east side.			
2	80	74	9½ a. m.						
(South end) 3	81	*85	3 p. m.	74 70½ 70½ 64½ 76½ 75		west side.			
4	80	85	3 p. m.						

*In the sun. †Not recognized.
‡These springs may not be identical with those examined in 1877.

Name of spring.	Observations in 1877.			Observations in 1871 by United States Geological Survey.			Observations in 1843 by Frémont.		
	Temperature of spring, Fahrenheit.	Temperature of air, Fahrenheit.	Time of observation.	Temperature of spring, Fahrenheit.	Temperature of air, Fahrenheit.	Time of observation.	Temperature of spring.	Temperature of air.	Time of observation.
	°	°		°	°		°	°	
Bluff Springs … No. 1	78	*85	2.30 p. m.	58	…	…	…	…	…
No. 2	78	85	2.30 p. m.	76½	…	…	…	…	…
				77½	…	…	…	…	…
				77½	…	…	…	…	…
				71½	…	…	…	…	…
				71½	…	…	…	…	…
Hooper Spring …	53	78	5 p. m …	53	…	…	…	…	…
Mud Springs, near Hooper Spring.	…	…	…	62½	…	…	…	…	…
Mud Spring, near village …	…	…	…	61½	…	…	…	…	…
Pavilion Spring …	52	82	2 p. m …	58	…	…	…	…	…
Small springs near Pavilion	…	…	…	53	…	…	…	…	…
				54½	…	…	…	…	…
				55	…	…	…	…	…
				55½	…	…	…	…	…
Formation Spring …	…	…	…	53½	…	…	…	…	…
Spring near Hill Spring …	…	…	…	68½	…	…	…	…	…

* In the sun.

The thermometers used in 1871 were ordinary thermometers, while those used in 1877 were made especially for taking the temperatures of springs. The table just given shows that very few of the springs can be classed as thermal, few if any, except the Steamboat spring, exceeding the temperature of the air. Observations should be made in the winter, however, to determine whether the temperatures exceed the mean annual temperature. Some of the springs exposed to the direct rays of the sun are evidently raised in temperature.

One cannot help being reminded as he wanders among the extinct spring-basins that they are dying out, and long ago must have been wonderful in their dimensions and phenomena. As Dr. Hayden has said, "At this time they may be called simply remnants of former greatness."

The formation of the cones is similar to what is seen in the cones of hot springs, viz, the overlapping of successive layers. It is, therefore, exceedingly probable that these springs were once all boiling or at least hot springs.

A few miles east of the village of Soda Springs at the mouth of a small cañon there is a collection of sulphur springs and a pool or lake, the surface of which is agitated by the escape of carbonic acid gas and sulphuretted hydrogen, which fills the surrounding atmosphere. The

water is cold and acid in reaction. The earth and stones surrounding are coated with sulphur.

The north and east sides of the valley of the Bear, near the springs, are floored with basalt, which does not extend across the river but leaves a broad valley of Quaternary between the river and the mountains. At the bend of the river the valley is only a little over a quarter of a mile in width. The river is on the south side in a cañon, the walls of which on the north side are basaltic, with irregular columnar form. On the south are the limestones of the northern end of the Bear River Range. This point, according to Frémont, has been named Sheep Rock. From this gap the Bear passes out into Basalt Valley.

SODA SPRINGS VALLEY.

The valley of Soda Spring Creek extends from Bear River northward to the plain of the Blackfoot, already described, and, as in the latter, the floor is basalt. The source of the flow is found in the craters near the Blackfoot. The slope of the valley is to the southward. Near the hills walls of basalt are seen, in which an irregular columnar structure was seen. There are numerous fissures and sink-holes, and whatever drainage there is from the hills, with the exception of Soda Spring Creek, sinks beneath the basalt. The Aspen Ridge, which is the eastern boundary of the valley, has been already described. On the west are the Soda Springs hills.

SODA SPRINGS HILLS.

North of the bend of the Bear, continuing northwest from the Bear River Range, is a low range of hills. Geologically and topographically this range is divided into two groups by a flow of basalt, which has poured out from the basin of the Blackfoot into Basalt Valley. The southern of these two groups consists of comparatively low ridges. Two stations were made on them. Station 87 is at the north end of the most eastern of the ridges, on limestones, which dip to the northeast. Station 88 was at the south end, on quartzites. These beds may be Carboniferous, although it is probable they are Jurassic, as Carboniferous fossils were found on the west side of the hills, in beds some distance below, at the base of the hills, near Twin Springs (see p. 563, chap. IV.)

The ridge on which these stations are located is about 800 feet above the valley of Soda Spring Creek, and the highest point in the group of hills is only 1,200 feet above the level of Bear River at the bend. The dip of the limestones is from 15° to 30°.

On the west side of the hills there are remains of old hot springs at several places, especially at Twin Springs. The basalt that separates the southern group from the northern seems to form a divide in Basalt Valley between the drainage of the Portneuf and that flowing to the Bear. The latter, however, is for the most part beneath the basalt. The northern group of hills forms the eastern boundary of the Upper Portneuf Valley. The elevation above the valley is only about a thousand feet. The summit is flat-topped, so that the general character is somewhat plateau-like. The western part of the hills, as at Station 82, is undoubtedly Carboniferous, with the limestones dipping to the northeast. On Station 70, however, we have Jurassic dipping to the southwest, so that between the two points there must be a synclinal. This would require, therefore, that the eastern portions of the hills be made up of Jurassic strata. The immediate region was not visited, but judging from the outcrops surrounding, this must be the case. I am inclined

to think that there is no faulting, as there is ample room for a fold, and faulting is not common in this immediate neighborhood. The point where I crossed the synclinal, if it exists, was covered with basalt, which effectually concealed the underlying beds. Mr. St. John's report, when published, may throw some additional light on the subject.

BASALT VALLEY.

As we come from the Upper Portneuf Valley to the Bear we find the broad valley continuous to the southward as far as the lower end of the Gentile Valley. The portion between the Portneuf and the Bear has been named Basalt Valley for convenience in description. Geologically it is continuous on the south side of the Bear, Gentile Valley being in reality the lower valley bordering the Bear after it flows out from the Basalt.

Basalt Valley is about seven miles in width, reaching from the Soda Springs Hills to the eastern ridges of the southern extension of the Portneuf Range. As the name implies, it is floored with basalt. The source of this lava is partly in the Blackfoot region, as we have already indicated, and partly in the craters near the bend of the Bear. In the latter place there are at least two that are very regular in their outline. On one of them Mr. Gannett made a station. It is almost circular, composed of a reddish scoriaceous basalt, resembling that of the craters already described on the Blackfoot. Near the craters the basalt is full of fissures and holes, some of them 50 or 60 feet in depth. The streams that come from the hills probably flow beneath the floor, so that the true divide between the Portneuf and the Bear cannot be determined. Near the west side of the valley, toward the north, there is one small stream that flows on the basalt to the Portneuf. Standing on the west side of the valley the flow of basalt is readily traced to the gap in the Soda Springs Hills. The basalt in the Portneuf Cañon is a prolongation of this lava stream. At Twin Springs there are remnants of old thermal springs, as at several other localities along the base of the hills. The most of them are, however, overgrown with grass, which conceals the tufa.

In the basaltic cañon of the Bear, near where it turns to the southward, there are calcareous deposits, as seen from the edge of the cañon. The springs are probably all cold at present.

South of this point there is an old crater similar to those seen north of the river. The southern extension of the basalt ends in a tongue, which will be described under the head of Gentile Valley. Almost the whole of Basalt Valley is rough and broken into fissures. There is a rather scanty supply of soil, and yet there is good grass interspersed with the sage, so that it would make a tolerably good cattle range, especially as the grass in the neighboring hills is of good quality. On the streams as they emerge from the mountains a small area of arable land may be found, but it is limited to the edge of the hills. Timber on the hills is somewhat sparse. The mass of basalt which can be traced from the Gap in the Soda Springs Hills forms a scarcely perceptible divide in the northern portion of the valley. It appears that the basalt poured through it and then spread to the northward and southward. The northern portion continued on down the cañon of the Portneuf. All the basalt we see in the valley is evidently one flow, but there are several points which seem to indicate that there were at least two flows. One of these points is in the Portneuf Cañon and the other in Gentile Valley. These two flows were separated by a layer of conglomerate. It therefore appears probable that the first outpouring was into a lake

which continued after the flow. In the volcanic action of this period perhaps a portion of the cause of the extinction of the lakes is to be found. We find no lake deposits resting on the latest flow, and in the lower Portneuf Valley we have already seen that a period of subærial erosion intervened between the draining of the lake and the last outflow of basalt.

BEAR RIVER RANGE.

West of Bear Lake Valley, separating it from Cache Valley and Gentile Valley, and extending north to the bend of Bear River, is the Bear River Range. It terminates in a broad, round summit known as Sheep Rock. This northern portion is very narrow and has a trend of about north 20° west. South of this the range becomes broader, although it decreases somewhat in elevation to North Pass. Still farther south the structure becomes somewhat complex, and the entire width of the range is about 16 or 17 miles. The waters of Logan Fork flow southward in the central portions of the mountains. The best defined range here is on the west, a succession of sharp peaks extending northward from Logan Cañon. This range or sub-range presents a steep and rugged front towards Cache Valley. On the east side the mountains are plateau-like, and this is the general character towards the north. The southern portion of the range is drained almost entirely by Logan Fork, which occupies a broad valley, for the most part in Silurian or Pre-Silurian? rocks. Our examination was not sufficiently detailed to separate the beds so as to recognize the various divisions, and on the map I have been obliged to color all the beds below the Carboniferous as Silurian.

Speaking of Logan Cañon, Mr. Arnold Hague says:* "At the forks of the cañon, the beds rise more steeply, and a quartzite belt is seen which may correspond to the Ogden quartzite. In the north fork of the cañon, fragments of granite indicate the probable existence of a granite core to this ridge beyond the limits of the map to the north." These were not seen by us, nor was the head of the north fork visited, but if granitic rocks do show, the outcrop must be limited to the cañon, for at the points where we crossed the range to the northward no granites were seen. At the entrance to Logan Cañon limestones outcrop dipping from 30° to 35° to the eastward. This gradually decreases until the beds gradually become horizontal and then rise again with a western dip. The following is a general section made as we hastily rode up the cañon:

Section No. 30.

1. Very dark blue limestones somewhat laminated, dip 35°.
2. Bluish-gray limestones, dip 25°.
3. Rather massive blue limestones, dip 20°.
4. Shaly and laminated limestones, dip 15°.
5. Light blue massive limestones, dip 10°.

The total thickness of these limestones must be about 4,000 feet. From about the middle of the cañon the following fossils were obtained:

Productus ——— ?
Rhynchonella pustulosa.
Rhynchonella rockymontanus.
Euomphalus ——— ?
Spirifer striatus.
Spirifer rockymontanus.
Spirifer (Martinia) ——— ?
Athyris (Spirigera) subtilita?

* U. S. Geol. Exploration of the 40th Parallel, Vol. II, page 407.

These correspond very closely to fossils found in the same beds by Mr. Hague. He refers the limestones to his Wahsatch Group, the lower portion of which he considers as Devonian. At the forks of the stream the dip to the westward is 15° or 20°, and lower beds appear. The general section in the bluff on the North Fork facing the east is as follows:

Section No. 31.

1. Massive limestones.
2. Laminated limestones and shales.
3. Massive blue limestones.
4. Dark blue limestones.
5. Thin laminated limestones, with bands of sandstones and slates.
6. Sandstone, with fucoidal markings and interlaminated limestones.
7. Laminated limestones.

Station 125 was located on the east side of the North Fork on a white saccharoidal limestone which lies at the top of the massive blue limestones (No. 3 of the section). This was merely a fragment capping the hill. They dipped to the westward and contained *Leptopora* ——— ? and *crinoidal* stems. In the limestones below I found *crinoidal* stems and an undeterminable *Rhynchonella.*

In layer No. 5, running down to 6, the following were obtained:

Orthis like *O. plicatella.*
Fragments of *trilobites.*

In No. 7 similar forms were found, and at the forks an *Orthis* like *O. testudinata.* Looking north from the station, the beds on the east side of the North Fork, at a point about 5 miles north of the station, appear to dip to the eastward, so that there is probably an anticlinal axis a little to the east of the station. On the west side of the North Fork there were some dips seen from a distance that seemed to indicate that the synclinal which enters into the formation of this portion of the range gradually dies out to the northward as the beds rise. If so, the western dip noted at the forks must soon give place to an eastern dip, and the anticlinal axis just noted must also fade out.

On Station 111, which is a little north of east from Station 125, and nearly six miles distant, the beds dip gently to the westward, and just west of the station there is a bluff face. Between this point and the North Fork there must be a synclinal. This, as we shall presently see, probably continues northward and forms the principal part of the range.

Returning again to the western sub-range, we found that the limestones that outcrop at the mouth of Logan Cañon rise as we go to the northward, and outcrop only at the summit of the range when we reach Station 123. Following up the main cañon of the creek that flows through Smithfield, we have first limestones which show somewhat obscurely, dipping about 17° south of east. Above the limestones are reddish quartzites, and then come thin yellowish argillaceous slates that are highly calcareous. Next follow limestones and a layer of slates like those below the limestones. In some of the layers of the upper slates the surfaces were covered with impressions of a *Discina.* Above these are massive limestones as far as I penetrated up the cañon. Mr. Mushbach reports that blue limestones outcrop on the station, and a little below is a white quartzite in which a fragment of *Productus* was found. Below this he noted a reddish quartzite with fucoidal markings. The latter is probably the same as layer No. 6 in the section at the forks of Logan Cañon; if so, the limestones above are the same as Nos. 4 and 5, which are probably Carboniferous.

Station 114 is located on the north side of Bloomington Creek, be-

tween it and North Creek. The latter stream flows to the northward with a course a little east of north, while Bloomington Creek flows directly eastward. The station is located on a dark-drab almost black limestone, which rests on a white quartzite. In the limestone I noted *Zaphrentis* and crinoidal markings. These limestones dipped gently to the eastward, becoming flat and again rising gently with a dip to the westward. They appeared to be a remnant left in a synclinal that was very shallow. They appear to outcrop on a mountain at the pass near the head of the creek, and there dip 25° to the eastward, or perhaps a little south of east. A little east of south from the station, on the other side of the creek, the underlying quartzites dip 5° to the westward. Below the quartzites are limestones, and below the latter dark quartzites generally of a reddish hue. The latter beds, a couple of miles northeast of the station, dip 20° to the westward. On Station 112, which is 16 miles further south and a couple of miles to the eastward, the dip is also west 5° to 10°. The latter station is on quartzite and below it are blue limestones. These westward-dipping beds are the western members of the anticlinal of Swan Creek. The eastern side has been so eroded that only occasionally can it be seen. It appears, therefore, that the synclinal east of Station 111 becomes prominent as we proceed northward and forms the principal portion of the range. At the north the quartzites appear to pass beneath the Pliocene deposits, north of which the geology has not been very closely studied on the south side of the Bear. North of the river, however, we have Jurassic limestones entering into the folds of the Carboniferous. Nothing can be predicated of this northern portion of the range until after it is visited and investigated. While the topography of this portion of the range was worked I was obliged to work the region of the southern branches of the Blackfoot which was much complicated geologically. At Sheep rock the limestones are probably Carboniferous. Station 91, which was the most northern station made by Mr. Gannett, had outcrops of massive light-colored limestone without fossils. On 95 quartzites outcrop, but of what age I cannot say, as no fossils were brought in.

Returning again to the southern portion of the range, we see that on our south line the range consists of a synclinal on the west of Carboniferous rock. Then follows an anticlinal of Silurian; next a synclinal, on the eastern side of which the Carboniferous appears again at Station 111. Then another anticlinal fold is noted, which is concealed west of Bear Lake by the unconformable Wahsatch beds. South of our district the range is much simpler, consisting of only one broad anticlinal, with a secondary fold developing on the west side. This is the western synclinal we have noted. Followed to the north it broadens as the beds rise, and finally disappears, while the eastern synclinal forms the main portion of the range.

GENTILE VALLEY.

Gentile Valley lies west of the northern end of the Bear River Range and directly south of Basalt Valley. It is about 16 miles in length, and about 4 miles in width at the lower end. Bear River enters the valley flowing south along the western edge of the basalt flow, which ends in a tongue-like projection. The river-bottom is broad and meadow-like, often marshy, and the stream is very sluggish. A trip of a day's duration was made into the valley from Mink Creek and two stations located. One (*a*) was located at the mouth of Trout Creek, and another (*b*) on the west side of the Bear south of Collier's Creek. Station *a* was located on soft, sandy, and marly beds, which were so broken down that a section

could not be made. On the edge of the river below the station two openings had been made in the bluff, evidently in search of coal, as there was a layer of earthy lignite outcropping. In the soft sandstone in the roof of one of these openings I obtained the following:

Planorbis ——— ?
Limnaea ——— ?
Sphaerium ——— ?
Valvata ——— ?
Carinifex ——— ?

This layer is probably the same as the one above Soda Springs, on Bear River, containing *Planorbis*, &c. North of the station these modern beds disappear beneath the basalt; westward they lap on the older rocks, and to the eastward seem to rest horizontally on the flanks of the Bear River Range. There appear, however, to be points of older beds rising above them. Station *b* is on such a point on the west. Opposite Station *a* there is a line of basalt showing in the face of a low bluff as though it had been poured out before the lake had deposited all its sediments. It was not visited, and may be simply the remnant of a flow that once extended across the entire valley, and has since been removed in the erosion of the river-bed. I am inclined, however, to consider it and the mass between the Bear and Trout Creek, at the mouth of the latter, as an earlier flow. The basalt field, a little farther north, rests on the soft sands, but its elevation was not obtained. Station *b* was located on pink and white quartzites dipping 40° south 77° west. These quartzites appear to have been an island in the lake not far from its western shore. Just below it is an outcrop of a rusty-looking conglomerate composed of pebbles of pink quartzite cemented by sand. The pebbles are 3 or 4 inches in diameter, and are like the quartzite of the station. This conglomerate appears to be at the top of the deposits that fill the valley and makes a terrace level, the elevation of which is 5,526 feet. There are three other well marked terraces. The lower terrace has an elevation of 5,186 feet, and the middle one of 5,242 feet.

On Cottonwood Creek, the largest branch of the Bear, coming in from the west at the head of the cañon, there are a number of terraces that have been cut by the stream. Near the head of this stream Pliocene? strata outcrop, but they were only seen from a distance, and were not visited.

Springs.—At the mouth of Cottonwood Creek, on the north side, there are a number of warm springs. They are on a large reddish mound composed of calcareous deposits. There are five large pools from 30 to 50 feet in diameter. A few bubbles of gas were noted in two of the larger pools. We did not have a thermometer with us, but the water seemed to be of a suitable temperature for bathing purposes. Farther up the river on the edges of some buttes of the soft lake deposits calcareous tufa was seen, and on the east side of the Bear, just above the head of the cañon, there are several springs on calcareous deposits with luke-warm water. On the edge of the river there are bubbling springs like those at the Soda Springs locality. Some resemble the Steamboat Spring, and the water spouts several inches or a foot above the mounds. In the midst of the river also there are points from which gas escapes.

The earthy lignite that occurs near Station *a* appears to be in pockets, as I could see no well-defined bed. Those who made the openings appear to have reached the wise conclusion that the coal was worthless. Gentile Valley appears to be comparatively well settled. The general elevation of the river-bottom is about 5,000 feet. From the view ob-

tained, looking north from Station *a*, it appears that the valley must have had some of the lake deposits removed prior to the pouring out of the basalt. The latter is at a lower level than the conglomerate at Station *b*. The amount of erosion since the flow is measured by the depth of the cañon in the basalt at the north end of the valley; this is 250 to 300 feet.

I did not visit the mountains on the west and east sides of the valley, so cannot give any definite information as to the relation of the lake-beds with the older beds of the ranges.

The conglomerate of Station *b* is probably of the same age as the conglomerate in the synclinal depression east of Station 76. There is but little doubt that the lakes filling these valleys were connected. The Pliocene lake probably had the greatest extent, and included what were afterwards divided into several distinct bodies of water.

MIDDLE CAÑON OF BEAR RIVER.

I have applied this name to the cañon through which the Bear flows on its way from Gentile Valley to Cache Valley. It is about 12 miles in length, and the walls are from 1,000 to 1,500 feet in height. A station was made on the west side, at the head of the cañon, about 800 feet above the level of the river, on dark-blue laminated limestones, which dip about north 17° east at an angle of 40° or 50°. Where the beds cross to the east side the strike seems to curve around to the southward, so that the dip is more to the eastward. On the hills west of Mink Creek, about four miles south of the head of the cañon, brownish quartzites outcrop with a strike south 67° east, dipping north 23° east, at an angle of 50°. Near the south end of the cañon the beds dip more to the south, with an angle of 65° noted in limestones. The quartzites lie between the limestones at the head of the cañon and those at the foot. We had two sub-stations (*a* and *b*) on the east side of the cañon. The hill on which station *a* was located was covered with quartzitic pebbles, and it is probable that quartzites underlie the station. Station *b* was on a dark limestone which dip 50° approximately to the south, as already noted. Between the two stations the following beds were noted:

Yellow sands and marls.
White limestones and shales.
Pea-green shales and sands.

There is probably 600 or 700 feet of these beds which I consider to be of Pliocene Tertiary age, as they are so much like the beds containing *Limnæa*, *Planorbis*, &c., at other localities. They dip north 23° east at at an angle of 65°. They are, therefore, unconformable to the limestones. The outcrop crosses to the west side of the cañon. That region was not fully investigated, but there is very little doubt that the beds about the head of Cottonwood Creek are the continuation of the beds just described. The whole region was too cursorily examined to say much about it. Where the Bear leaves the cañon and bends westward to enter Cache Valley the greenish Tertiary beds outcrop on the southeast side, dipping 10° towards the south. They rise again a short distance beyond.

On the east side of Mink Creek, at Station 118, Gannett obtained a few fragmentary fossils which have a Silurian facies. The strata from which they were obtained have a westerly dip. Mink Creek has a course almost parallel to that of the Bear while it is in the cañon, and joins it as soon as it leaves the cañon to turn westward. Near the head of the creek an outcrop of shales was seen which appeared to rest un-

conformably on the limestones with a dip towards the west. The beds were obscure, and I am not certain as to their position and relations; they may represent a portion of the Pliocene.

At Station 116, massive limestones outcrop with dips to east or southeast. This region is exceedingly complicated and will require considerable close examination to determine the relations. The cañon of the Bear was probably in part eroded subsequent to the upheaval of the beds that I have referred to the Pliocene. When the orographic disturbance at the end of the Tertiary took place the basin of Gentile Valley was separated from that of Cache Valley. Whether the erosion of the cañon began then or after the draining of the lakes, I cannot at present say. The cañon is almost at right angles to the strike of the beds and must have been determined by a pre-existing fissure or a fissure made at the time of the uplift.

CACHE VALLEY.

The portion of Cache Valley that lies within our district is about 36 miles in length and from 7 to 12 or 15 miles in width. It is well settled by a prosperous farming population, and the land appears to be in a high state of cultivation, especially in the southern portion. The entire population is 8,229 by the census of 1870. The towns in our district are Franklin, Richmond, Smithfield, Hyde Park, Newton, Clark, Clifton, Weston, and Oxford. The town of Logan, which is the county capital, is only a short distance south of our line. The towns are generally on a streams coming from the mountains, and the water is used for irrigating the fields which surround them.

Geologically Cache Valley begins as a broad synclinal below our line, but north it probably overlies or occupies the place of several folds. The view of the valley from the surrounding hills is one of exceeding beauty, especially in August, when the fields are golden with the ripening grain. The groves of trees, which mark the towns, with their white and red buildings, stand out in strong relief. The whole valley can be seen at once, and the terraces on its sides and the basin-like character of the depression, point to its former character of a lake-basin. This is confirmed when we come to examine its deposits. As Dr. Hayden said in 1871, "Cache Valley opens into Salt Lake Valley," "and one cannot doubt that the lake itself formerly extended all over Cache Valley." An examination of the beds occupying the valley shows at least two groups of lake deposits: First, those that have been referred to the Pliocene, named by Dr. Hayden the Salt Lake Group; second, the deposits in the central portions of the valley. These I have named the Cache Valley Group. The former, as we shall see, are generally disturbed, and the latter are horizontal in position. The latter, on closer study, may have to be divided into several groups to correspond with the various lakes from which they were deposited. By this I mean that the terraces show a number of lake levels, and on the lowering of the lakes the areas became more restricted; so in the terraces we find groups of strata older as we go up, while in the centre of the valley the succession will be continuous. The drift has covered these beds to such an extent that the divisions cannot always be recognized, so that I have included them under one head. Until a series of level-lines are run, they cannot be outlined on the map.

I shall now present the facts obtained in relation to the different parts of the valley, beginning with Logan Fork, which is almost on our south line.

The terraces are well marked on the north side of the river, as shown in the accompanying diagram. At several places soft marly sandstones outcrop beneath the terraces, especially in the lower ones, with a dip. At the edge of Logan Cañon, and extending some distance above its mouth, are deposits consisting of gravels, sands, marls, and conglomerate, from 100 to 150 feet in thickness. They are horizontally stratified, showing that the lake extended somewhat into the cañon at one period subsequent to its erosion, and these beds represent the material brought down by the rapdily flowing stream, which then as now occupied the cañon.

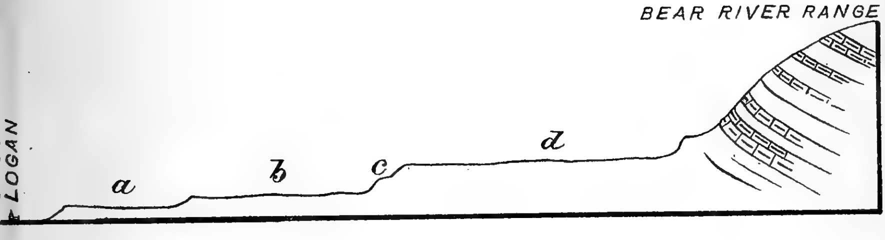
Station 122 was located a few miles northeast of Smithfield, on a butte that stands out a mile or two from the mountains. The rock on the summit is limestone. Surrounding the butte is a limestone conglomerate. This butte, therefore, was probably an island near the shore of the lake, whether Pliocene or Post-Pliocene I could not determine, but probably the former, as heavy beds of similar conglomerate were seen farther north which appeared to be of that age. Six or seven miles farther north a similar butte appears, which was not visited. The latter has an elevation of 5,400 feet and the former 5,638 feet. Franklin Butte is much lower and is about four miles west of the edge of the mountains. Its elevation is 5,324.* It must, therefore, have been an island at lower levels of the lake. It is composed of limestones, probably Silurian in age, although no fossils were seen. On the summit fragments of white limestone were seen resembling the Pliocene limestones, and exactly like the fragments seen at Station 131. If these are Pliocene, as I believe, it may indicate a period of erosion following the uplift at the end of the Tertiary time, and before the Quaternary lake filled the basin of the valley. There are two well-marked terrace levels on the side of the butte and several minor ones that are not well defined. In the bank of Cub River, at Franklin, gravels and loosely aggregated sands show and are horizontal. In the accompanying diagram the profile from the butte to the river is shown with the elevations. The upper terrace level is 122 feet below the top, and the lower 437 feet. The sands on the banks of the river are the same as those shown on Bear River. East and northeast of the butte are a mass of rounded hills rising 1,400 to 1,500 feet above the valley. These do not show many outcrops, but the few seen were of sandstones and conglomerates. I have considered them as belonging to the Pliocene, although it is possible that the conglomerates may be more modern. It is exceedingly difficult to separate the formations with the limited data at hand. The terraces that are marked on the sides of Franklin Butte are outlined on these hills.

West of the middle cañon of Bear River these beds, or perhaps lower ones, show, resting on limestones, which appear to have been elevated with them. The outcrops are obscure. The terraces here are comparatively well marked.

At the point where the Utah Northern Railroad crosses Bear River, the more modern deposits are well shown, consisting of yellow and reddish sands, clays, and marls. There is an exposure of about 300 feet.

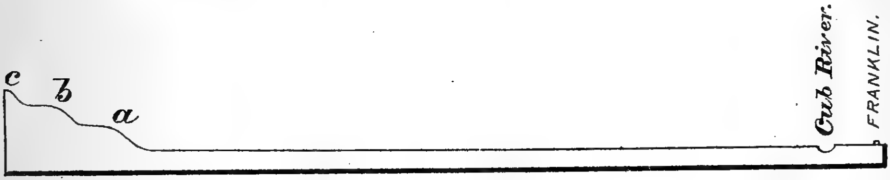
Returning to the south line of our district, and crossing to the west side of the valley, we find the Pliocene beds outcropping again in the foot-hills. At Mendon, a short distance below our line, the sandstones in some of the layers are made up of an aggregation of shells of the following genera, *Limnæa*, *Physa*, *Vivipara*, and *Helix*. At one of our camps on the Bear, just before it passes into the Gates, there were outcrops

* By angles of elevation and depression.



a 106 feet above Logan.
b 116 " " ".
c 201 " " ".
d 233 " " ".

Diagram of Terraces East of Logan.



Terrace a, 222 feet above valley.
" b, 537 " " ".
Summit c, 659 " " ".

Diagram of Terraces on Franklin Butte.

of greenish sandstone, with white and light brown limestones and shales; in the latter shells of the following genera were found:

Limnæa ——— ?
Valvata ——— ?
Planorbis ——— ?
Sphærium ——— ?

They are apparently identical with existing species. On the north side of the Bear a gray sandstone outcrops, which is probably above the fossiliferous layers. In the cañon as far as could be seen limestones outcrop. We had very stormy weather while here, and had to leave a number of points unvisited. On our south line a little west of south from the Gates, the Wahsatch Range ends in a high peak, around the northern foot of which the Pliocene beds extend from Cache Valley to Malade Valley.

The following notes on the region of the Gates is taken from Professor Bradley's Report for 1872, p. 199:

The immediate channel of Bear River, where it breaks through the mountain, at the point known as "The Gates," is narrow, with high precipitous walls of light drab, compact limestone, partly siliceous, from which I could obtain no fossils; but from its position it must be Carboniferous. The strata show a westerly dip of about 25°, and evidently belong to the west side of the anticlinal upheaval, whose southern continuation has been mentioned as crossing Box Elder and Ogden Cañons. The cliffs of this narrow channel reach nearly to the level of the top of the second principal terrace. On the north side of "The Gates," a short distance back from the edge of this channel, there is another considerable break in the upper terrace, showing a second channel to have existed when the stream was at this level; and as seen from this north side, the appearance of the surface on the south side indicated the probable existence of still a third old channel, along the line now occupied by the Utah Northern Railroad (narrow gauge), which there crosses the range into Cache Valley. At the level of the upper terrace the old valley of Bear River spreads out to a width of about five miles. The upper terrace itself consists almost entirely of a grayish-white limestone, partly fine-grained and compact, partly coarse and porous, and mostly pebbly. All of it is more or less oolitic. The compact layers are entirely destitute of fossils; but the more pebbly portions contain very numerous individuals of a few species of fresh-water shells, which are sufficient to mark the bed as of late Tertiary (Pliocene?) age. * * * The beds exposed are about 200 feet thick. They show at this point a dip of about 25° south 68° west. As no corresponding disturbance of the surface of the terrace is apparent, it is evident that the upheaval antedates the Terrace epoch. The lower terraces show extensive deposits of coarse gravel, which are well exposed in the cuts of the Utah Northern Railroad, and supply that road with an abundance of superior ballast.

There are knobs of limestone both north and south of the cañon, and at a point about four miles south they outcrop at the base of a bluff.*

East of the south end of the Malade Range, the sandstones and shaly limestones of the Pliocene again outcrop, dipping to the eastward 5° to 10°, as at the Bear. Here also I obtained the following:

Planorbis ——— ?
Sphærium ——— ?
Bythinella ——— ?

East of this locality is a high butte of the same beds. At the eastern base limestones probably outcrop, but of what age I do not know. North

---

*According to the Report of the United States Geological Exploration of the 40th Parallel, Vol. II, Description, there is volcanic outcropping in the cañon. The following is the note: "An appearance of volcanic rock in the cañon of Bear River, at the 'Gates,' which, however, was not examined closely enough to determine definitely its character, suggests the possibility that this uplift may have been determined by a late volcanic outburst." This volcanic rock Professor Bradley does not appear to have seen, nor did I.

of this butte is one similar to it south of Weston Creek. Weston Creek rises on the west side of the northern portion of the Malade Range, in Pliocene rocks, and cuts through the Silurian rocks to come out into Cache Valley, where it again cuts its way through the Pliocene (?) deposits. Near this point is a synclinal of these Pliocene beds, coarse conglomerates outcropping. They appear to rest in a synclinal in the older rocks, which are dark limestones, beneath which dark-green chloritic and metamorphosed argillaceous slates outcrop. The Pliocene beds appear to reach high up on the mountains, and seem to dip with the older rocks, although there is little doubt as to their unconformability. The softness of these more modern beds causes them to break down readily under atmospheric influences, and their junctions with the older rocks are thereby much obscured.

At the north end of the valley, on the southern slopes of the Portneuf Range, these Tertiary beds appear to be present in considerable areas. They were not visited but seen from the valley. As we approach Red Rock Pass, a conglomerate is seen resting on the quartzites, which outcrop irregularly, as though they had formed an uneven floor upon which the conglomerates were deposited. It is probable that a large portion of the lake deposits has been carried away from this part of the valley. Whether there are any of the soft sands and marls near the pass, I could not determine, but I think not. If they ever did exist here they have been carried away by the draining of one of the lakes that existed in the valley.

MALADE RANGE.

Under this head I shall describe the two ranges that separate Cache Valley from Malade Valley. The northern portion ends at Weston Creek, having a length of about 20 miles. It ends just southwest of Red Rock Gap. The southern range begins about 4 miles north of the "Gates" of Bear River, and extends a little west of north for about 25 miles, overlapping the south end of the northern portion, which is 6 miles farther east. The country between is filled with the Pliocene (?) limestones and sandstones which are here continuous from Cache Valley to the Malade Valley.

Northern range.—This range, as I have already said, is some 20 miles in length. Its highest peaks rise 4,000–5,000 feet above the valley at the east base. It is really composed of two groups which are separated by a comparatively low saddle. The view from Station 132, looking down on this saddle, appeared to show the whitish Tertiary beds reaching well up on it from the west. The station (132) is the highest point in the northern mass. A very abrupt face is presented toward the east. On the ridge extending south limestones outcrop with shaly beds (limestones?) above them. They dip slightly north of east, and appear to rest on the green chloritic rocks that outcrop on the slopes lower down. On the summit the following is the section, which corresponds with the accompanying diagram, which shows how the eastern face of the mountain is eroded:

Section No. 32.

Top.	Thickness in feet.
1. Red quartzite	900
2. Red sandstone shales	
3. Red quartzites, conglomeritic at base	
4. Very dark red conglomeritic quartzites	
5. Space in which limestones probably outcrop (the connection with the following portion of the section is somewhat obscure)	

Thos. Sinclair & Son, Lith

FRANKLIN BUTTE AND NORTH END OF CACHE VALLEY.

		Thickness in feet.
6.	Dark-green chloritic schists, with serpentine	350
7.	Metamorphosed argillaceous slates, yellowish-brown in color	
8.	Pink quartzites, 200 feet	
9.	Very dark green chloritic schists, with white quartz veinings. These rocks are very irregular in their weathering	
	Total	1,250

On a point south of the station the dip in the red quartzites was 30° north 77° east. On the station the strike was south 7° west, dip south 83° east, angle 30°. There would, therefore, appear to be a swerve to the eastward in the strike toward the south. Toward the north the green beds, which I have referred to the Cambrian, appear to sink somewhat, so that the Tertiary beds south of Marsh Creek appear to rest on limestones that belong to a higher horizon. The southern mountain mass on which Station 130 was located is rounded in outline, and reaches an elevation of 8,395 feet. There appears to be some Tertiary on the summit. Below it are limestones, next olive-green shales, followed by red quartzite, and then some 500 or 600 feet of limestones. The base of the latter, I think, is the same that outcrops at the south end of the range where Weston Creek comes out of its cañon. At this point the limestones are filled with fragments of *trilobites* and other Silurian forms. South of the range there are several isolated outcrops of Tertiary beds which appear to have been islands in the Tertiary lake. The northwest portion of the northern range is drained by a branch of Marsh Creek, which at its head appears to be in Silurian rocks, although there may be isolated patches of Tertiary. The central western portion of the range has its drainage collected into Malade River. The main stream heads opposite the head of Weston Creek. The rocks in this region are almost entirely the white and light-brownish limestones and greenish shales and soft sands so characteristic of the Pliocene.

Southern range.—This portion, like the northern, is divisible into two masses. The southern is the most prominent, and is separated from the northern by Tertiary beds. This southern mass of hills is about eight miles in length and about three miles in breadth. Two topographical stations were made on this part of the range, one at the north and the other at the south. At the latter place light-colored limestones with easterly dips show. These limestones have fragments of crinoidal stems, and are probably Carboniferous, although the mass of the mountain is probably Silurian. The northern station appears to have westerly dips, so that the range, if these dips are correctly reported, is a synclinal. Southwest of the range the Pliocene limestones cover the foot of the mountains, dipping from them. On the east they also occur dipping eastward. The northern portion of this southern or western subrange is a long, narrow crest of Silurian limestones that present a rather steep face toward the Malade Valley. The eastern slopes are covered with the thin-bedded Pliocene deposits which are mostly eroded on the west. I did not follow the western face of the mountains, having crossed to the western side of Malade Valley north of Malade City. Professor Bradley, in 1872, made a close study of this portion of the range, and I quote from his report (p. 200):

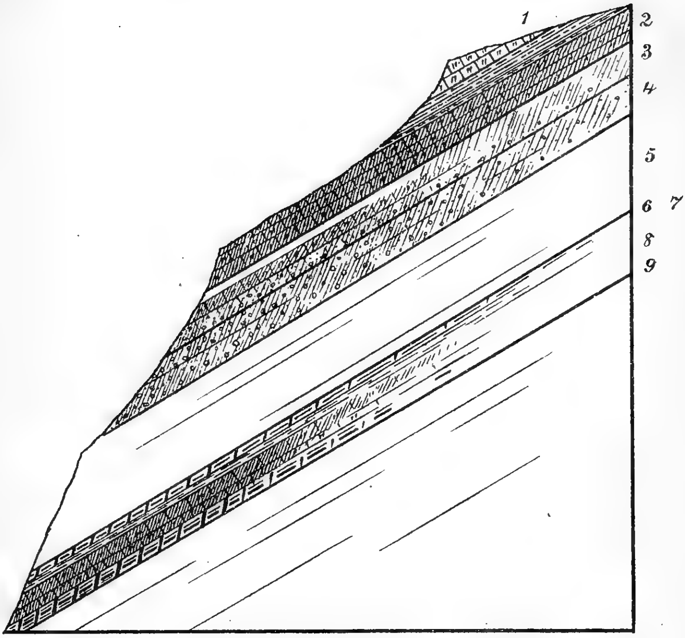
After crossing Bear River, the Tertiary limestones are found covering the entire foot of the mountain for two or three miles, though the mountain itself is still plainly composed of the older limestone, which appears on its summit. Then the Tertiary disappears altogether, and the upper quartzite rises so as to form the face of the ridge for four or five miles, then the Tertiary comes in again, in a heavy body of compact flinty limestones and siliceous shales, running to the very tops of the hills, which are

here much depressed. The strata are mainly nearly level, only the portion nearest the valley having a westerly dip, which at some points reaches 40°. About nineteen miles above Hampton's Bridge the mountain rises again and the Tertiaries disappear again, exposing the face of the lower limestone, which has now risen so as to form the entire mass of the mountain. At the junction of the two series of strata it is evident that the Tertiaries lie unconformably upon the older limestones, many layers of which are here crowded with fragments of trilobites and other fossils, which are plainly of the age of the Quebec Group. * * * As we approach Malade City the mountain becomes higher and more precipitous, a point about three miles south of that place being found to be about 2,500 feet above the river. Of this total, about 2,000 feet are exposed in the face of the mountain, the terraces being mostly washed away. All the strata exposed belong to the Quebec Group, and consist mainly of limestones, though including, perhaps, 200 feet wall of sandstones, partly shaly, but mostly thick-bedded and quartzitic, as well as an indeterminate amount of interlaminated greenish calcareous shales. The uppermost limestones are compact and full of nodules and layers of chert; the lower ones vary greatly, from pure compact to coarsely fragmentary, to a fine-grained siliceous, and to oolitic and coarsely concretionary forms. The colors vary from drab to blue, gray, buff, flesh-color, and pale red, sometimes uniform, sometimes mottled and streaked.

These beds are all probably higher than the quartzites observed on Station 132, and seem to correspond closely to the beds of Section No. 21 made at Station 133. The fossils from the latter place seem to prove their identity. North of the north end of the subrange just described, quartzites, with Quebec limestones overlying, outcrop with dips to eastward with an angle of 40° or 50°. These beds extend to the divide between Malade and Marsh Creek, and just north of the divide they dip north 27° east. The region between this ridge and Station 130 is rather heavily timbered, and I am not certain as to the relations of these quartzites and limestones with those of Station 130. The station was too high to determine them. I could not see the dark-green beds outcropping on the west. It is possible there may be a fault here, but nothing was seen that indicated it. Between the two portions of the range I am inclined to think there is a synclinal which has been much eroded, leaving the present ranges as remnants. These, without doubt, formed islands in the Pliocene lake and towered also above the Quaternary lakes that bathed their slopes still later. What the relations of the dark chloritic slates of Station 132 are to the beds of the section (No. 22) made at Station 78, I cannot say. The quartzites above resemble those above the argillaceous slates at Station 77, but the green beds are very different. There is scarcely any doubt, however, of their being referable to the Cambrian in both cases. I think the limestones of Red Rock Gap are below the quartzites that lie below the section of Station 133. A little more study of these localities will render clear what are at present problems and matters of conjecture. I can only hope to point out the localities and state the facts as far as observed by myself, leaving it to others to work up the minor details, which will prove to be the connecting links, and which will make clear the points that are now so obscure.

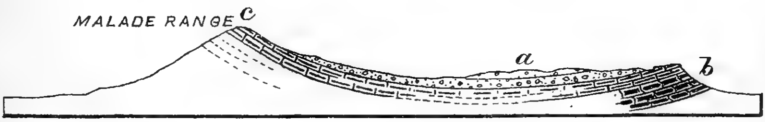
MALADE VALLEY.

Malade Valley, within our district, has a length of about 40 miles. The upper portion is basin-like, having a width of about 10 miles. After the various streams unite at the lower end of this basin the valley narrows to some four or five miles. The principal town is Malade City, with a population of 591 in 1870; the present population is greater. The town is the county-seat of Oneida County; Samaria is a town on the west side of the valley at the foot of the hills. In the lower portion of the valley there are two small settlements, viz, Portage and Plymouth. The entire population of the valley is 994 (census of 1870). The Malade



East Figures refer to Section No. 32.

East face of Malade Range. at Sta. 132.



a, Pliocene. b. Cambrian. c, Silurian.

Synclinal of Pliocene beds on Weston Creek.

see page 606.

F. D. O.

River is a sluggish stream with a muddy bed. The water is somewhat alkaline, as it is in most of the wells sunk in the valley. The three principal streams that unite below Malade City to form the river are Devil Creek, Mill Creek, and the Little Malade. The first of these rises in the south end of the Bannack Range, opposite the head of Marsh Creek. On the east side of this creek the White Tertiary beds outcrop. The upper lake terrace extends almost to the divide, which, as Professor Bradley suggests, might have been a point of dribbling outflow for the waters of the great lake when at its highest level. It must have been when the lake in Marsh Creek Valley was at the level indicated by the upper terrace, and this divide was a point of connection between the two lakes, as the elevation of the divide is lowerthan that of the highest terrace in Marsh Valley.

The beds at the southern end of the Bannack Range are probably the continuation of those on the east side of the valley, as Professor Bradley speaks of finding characteristic fossils in the southern end of it.

The upper valley of the Malade has an elevation of about 4,700 feet, and is filled with soft, sandy, and marly beds. On the Little Malade there are bluffs of these beds about 50 feet high. Near Plymouth I found in these beds specimens of a *Limnæa*. Whether these beds are contemporaneous with those of Cache Valley or later I don't know, but they are more alkaline, and if the lake filled the valley after that of Cache Valley was drained, they are probably more modern. There are hot springs deposits at various points, and many of the springs still exist with slightly warm water.

As we have already seen, the Tertiary beds outcrop on the east side of the valley. On the west I did not see them. They are probably present beneath the more modern deposits. On some old maps the Malade is known as Roseaux or Reed Creek.

At Hampton's Bridge of Bear River the Bear is flowing southwest, but it now turns southward, and flows parallel to the Malade south beyond our district. Where they cross our south line they are only about a mile from each other. From this point the streams are both very sluggish. The river terraces on the Bear at the bridge are well marked.

BLUE SPRING HILLS.

The Blue Spring Hills lie on the west side of Malade Valley. Three topographical stations were made on them, the summit of the range forming the western line of the work done by us. The rocks are all Carboniferous, with western dips. Station 136 was on the hills west of the head of the Malade. Limestones outcrop on these hills dipping 15° south 27° west. Fossils were obtained from two layers on the eastern slopes of the hills. The following are the fossils:

Layer No. 1—*Zaphrentis* ——— ?
Fenestella ———.
Rhombopora lepidodendroides.

Layer No. 2—*Productus pratteniianus.*
Rhynchonella uta.
Spirifer striatus.

South of Samaria, the following were found:
Productus costatus var.
Euomphalus ——— ?
Aulopora ——— ?
Zaphrentis ——— ?

From Station 137, Mr. Mushbach brought in the following:

Euomphalus luxus.
Productus semireticulatus.
Spirifer rockymontanus.
Spirifer (Martinia) planoconvexa.

Mr. Mushbach reports that some of the limestones were almost entirely composed of masses of these fossils. These hills probably represent the western side of an anticlinal, the axis of which must lie towards the east side of Malade Valley. There may be a fault, but I saw no evidence of it.

CHAPTER VI.

RÉSUMÉ OF THE GEOLOGICAL FORMATIONS OF THE DISTRICT.

ARCHÆAN ROCKS—PALÆOZOIC ROCKS—MESOZOIC ROCKS—POST-CRETACEOUS—CENOZOIC ROCKS—VOLCANIC ROCKS.

In the present chapter I propose to review briefly the geological formations, and to state a few conclusions that appear obvious from a consideration of the facts presented in the preceding portions of the report. These facts are as yet too isolated, and the district too cursorily examined to afford reliable data for extended generalizations.

As is evident from the preceding chapters, the district is almost entirely a sedimentary area. In the northeastern corner we have Archæan rocks in the foothills of the Wind River Mountains, but the area is very limited. In the northwest the basaltic flows are somewhat prominent. No other volcanic rock was noted within the limits of our district. The sedimentary rocks are much folded in the eastern portion of the district, and accompanying this folding there was much vertical displacement. Toward the west the folds have been very much eroded, and the spaces between the portions left have been filled with lake deposits. The following table of the formations of our district presents the general section as derived from the detailed sections already given:

General section.

CENOZOIC.	QUATERNARY.		Drift.	?	2,815 +
			Salt River conglomerate.	?	
			Malade Valley Group.	?	
			Cache Valley Group.	230 ft.	
			Marsh Valley Group.	85 ft.	
			Gentile Valley Group.	?	
	TERTIARY.	PLIOCENE ?	Salt Lake Group.	700 + ft.	
		MIOCENE ?	Bridger Group. Green River Group.	1,000 +	
		?	Wahsatch Group.	800 +	
	POST CRETACEOUS.		Laramie Group.		4,000 +
MESOZOIC.	CRETACEOUS.		Fox Hills Group. Colorado Group. Dakota Group.	3,000 + ft.	8,500 +
	JURA TRIAS.	JURASSIC.	Belemnites Beds. Pentacrinus Beds.	1,500 +	
		TRIASSIC ?	Red Beds. Meekoceras Beds.	4,000 + ft.	
PALÆOZOIC.	CARBONIFEROUS. DEVONIAN ? UPPER SILURIAN ?		Carboniferous ? limestones.		6,000 +
	LOWER SILURIAN.	*Canadian.*	Quebec. Calciferous.	8,560 + ft.	9,810 +
		Cambrian or Primordial.	Potsdam Cambrian quartzites. Acadian Cambrian slates.		
	ARCHÆAN.		Huronian ?	1,250 ft.	
			Granite.		
			Total thickness of sedimentary formations		31,125 + ft.

ARCHÆAN ROCKS.

The Archæan rocks of our district are limited to the extreme northeast corner of the area where the foot-hills of the Wind River Mountains and a few isolated buttes are composed of a granite which is made up of a red feldspar and gray quartz and muscovite. These buttes appear to have been islands in the earlier Tertiary lakes. As the main mass of the mountains is within the limits of Dr. Endlich's district, I shall leave the discussion of these rocks to him. They underlie the soft beds of the Wahsatch Group, the lowest layers of which are evidently derived from the degradation of the granitic rocks. There is a slight inclination from the hills as though there had been some elevation of the Wind River Mountains subsequent to the deposition of the Tertiaries. The angle of inclination is greater than would be expected if the strata were merely deposited on a sloping bed. The mountains formed the shore of the lake all through Tertiary time, and probably towered above the Palæozoic seas from early time, as did the Rocky Mountains of Colorado, with which they were probably synchronous. There was probably also a contemporary subsidence. At any rate, the evidence appears to point to a subsidence of the range and that of the Green River Basin during Tertiary time. On the west side of the basin the Wahsatch beds rest unconformably on Jurassic and Cretaceous strata that were crumpled and folded prior to the existence of the later Tertiary Lakes. These older beds terminate to the eastward beneath the Wahsatch Group somewhere between the Wind River Range and the west side of the basin. The most prominent of the isolated granitic areas near the Wind River Mountains is Frémont's Butte. It is on the south side of Willow Creek, and rises 650 feet above the creek level.

In the preceding chapter I have referred to the fact of Mr. Hague finding granitic boulders in Logan Cañon. If there is a granitic area at the head of either of the forks of Logan River it must be very limited in its extent, probably appearing only at the bottom of the cañons. None were seen by us, and I merely mention the probability of the occurrence.

PALÆOZOIC ROCKS.

At no point within the district was I able to obtain a continuous section from the base of the Palæozoic to the top. In the east, the lowest Palæozoic outcrops identified are Carboniferous, and in the west the Cambrian rocks are the lowest and show by the erosion of the overlying beds; but at no place could I get an uninterrupted section from the lowest exposure of the Cambrian to even the top of the Silurian. The general section given is compiled from the various outcrops, which are, however, sufficiently connected to show that the entire section is conformable. It is possible that a portion of the base of the Carboniferous section as given in this report in the Wyoming and Salt River Ranges should be referred to the Devonian. In the absence of fossils other than Carboniferous I have included it with the Carboniferous.

In the Bear River Range, Devonian occurs according to the statements in reports of the fortieth parallel survey. We found no fossils, however, and, even if found, our examinations were not detailed enough to carry the subdivisions over the whole district, and I have not, therefore, separated the Devonian, in this western portion of the district, from the Carboniferous.

SILURIAN.

The recognized Silurian areas of our district all lie in the west half. The most eastern exposures were noted in the Bear River Range, but

our examination of this range was too cursory to enable us to present a section, as only the upper part of the series was seen here by us. Northwest of the Bear River Range there are larger areas of Silurian rocks, the ranges in that region being largely composed of them. It is a region of complicated folding, and the erosion of these numerous folds has left isolated mountain masses or short ranges in which Cambrian or Primordial and other Lower Silurian rocks are exposed. I obtained no fossils that would refer any of the limestones to the Upper Silurian. The general section already given is based on the system of Dana.

Cambrian or Primordial.—The best exposure of Cambrian rocks in our district is given in the section eastward from Station 77 (section No. 22). Here we have—

1. Dark-gray, almost black, quartzites and quartzitic sandstones, with indurated argillaceous slates; iron oxide appears to be characteristic of the lower layers of sandstones; some of the beds appear to be highly metamorphosed; thickness in feet	1,600
2. Silvery-gray and steel-gray micaceous slates; thickness in feet	1,900
3. Olive green and gray chloritic slates with fucoidal ? markings, with bands of quartzite and indurated clay slates; thickness in feet	1,560
4. Pink and white quartzites, conglomeritic at the top and underlaid by slates and limestones; thickness in feet	2,000+
Total	7,060+

The quartzites here I am inclined to consider as the same series as that given near Station 133 (section No. 21). In the latter place we have between 1,200 and 1,500 feet of quartzites, the lower portion being red and having a general resemblance to those of Station 77 (layer No. 4).

On Station 130 a similar red quartzite outcrops, but it has limestones just below, and below them a series of very dark green chloritic rocks, unlike those of any other section in our district. I am inclined to place these below the section of Station 77, and consider them of probable Huronian age. I shall include them in the section of the Silurian for the present. None of the sections exposed the underlying crystalline schists.

The beds given in the sections are probably equivalent to King's Cambrian shales and Cambrian quartzites. No organic remains were obtained from the rocks. Some of the layers appeared to have fucoidal markings, and also what might possibly represent traces of worms.

Canadian.—The Canadian period is undoubtedly present in our district as first determined in 1872 by Professor Bradley.

Above the pink quartzites of Section No. 21 is a series of greenish sandstones and shales with interlaminated limestones and quartzites with a thickness of about 1,300 feet. These beds lie below the limestones which contain the fossiliferous layers, and I have provisionally referred them to the Calciferous, confining the Quebec Group to the limestones above. The section, although the most complete made by me, does not extend to the top of the group. West of Malade City, the section gives 2,000 feet referred to the Quebec by Bradley. Mr. St. John has kindly furnished me with the following section made at Mount Putnam, beginning at the base:

a.—Quartzite.
b.—Dark greenish chloritic slates.
c.—Heavy deposit of quartzite, dip 85° eastward.
d.—Soft bluish micaceous shales.
e.—Heavy deposits of quartzite conglomeritic, in color pink, reddish and white with thin layers of micaceous shales, dip 80° eastward; locally 20° to 30° east-northeast, and 85° eastward.
f.—Dark red finely laminated sandstone, thick bed. Potsdam ?

The letters in this section correspond with those given in the illustration of sections across the Portneuf Range in Chapter IV.

From the position of these beds in relation to those of the section (No. 20) of Station 76, I am inclined to consider them as at the base of the Canadian, or perhaps all the equivalent of the Potsdam, although the section is somewhat like the top of Section No. 22. I think Mr. St. John is inclined to refer the base of the section to the Huronian. In the following section the double line separating the two portions indicates the line of greatest obscurity in the sequence.

The list of fossils following the section gives the localities of *undoubted* Silurian rocks throughout our district. I did not recognize any Upper Silurian.

Silurian section.

CAMBRIAN OR PRIMORDIAL.	POSSIBLY HURONIAN?		Very dark-green chloritic schists, containing quartz and serpentine seams and interlaminated bands of metamorphosed argillaceous slates, and a band of pink quartzite 200 feet thick.	900 ft.	1,250 ft.	Section No. 32, station 132.
			Limestones.	350 ft.		
			Red quartzites and quartzitic sandstones, with conglomeritic and shaly layers.			
	ACADIAN?	CAMBRIAN SLATES.	Dark quartzites with interlaminated slates.	1,600 ft.	7,060 + ft.	Section No. 22, station 77.
			Silvery and steel-gray micaceous slates.	1,900 ft.		
			Olive-green and gray chloritic slates and indurated clay slates.	1,560 ft.		
	POTSDAM.	CAMBRIAN QUARTZITES.	Pink and white quartzites, conglomeritic at top with thin layer of limestone at the base.	2,000 + ft.		
CANADIAN.	CALCIFEROUS?		Blue limestones, generally laminated with alternations of greenish sandstones and shales and siliceous slates.	500 feet.	1,500 + ft.	Section No. 21, station 133.
	QUEBEC.		Blue and gray limestones, with characteristic Quebec fossils.	1,000 + ft.		

Organic contents.

Fossils characteristic of the Quebec Group were found in our district in 1872, by Professor Bradley. The finding of these fossils marked the first identification of the group in the Rocky Mountains.

The following list of fossils near Malade City is quoted from the report for 1872 (p. 464):

Camerella calcifera Billings.
Orthis hippolite Billings. (?)
Orthis like *O. electra* Billings.
Euomphalus (?) *trochiscus* Meek.
Euomphalus (?) *rotuliformis* Meek.
Euomphalus or *Ophileta*.

Agnostus josepha, Hall.
Conocoryphe (several species).
Bathyurellus (*Asaphiscus*) *bradleyi* Meek.
Bathyurus saffordi Billings.
Bathyurus or *Dikelocephalus*.
Bathyurellus (*Dikelocephalus*) (?) *truncatus* Meek.
Asaphus (*Megalaspis*) (?) *goniocercus* Meek.

The fossils collected by us during the season of 1877 have not been carefully studied as yet, so that the list following is not complete. It is probable that many of them are identical with some collected by Professor Bradley.

List of Silurian fossils.

Bathyurus and other obscure Silurian forms.	Head of the middle cañon of Bear River at the South end of Gentile Valley.
Discina sp.?	Cañon east of Smithfield.
Orthis like *O. plicatella* *Orthis* like *O. testudinata*. Several species of trilobites.	Forks of Logan River, in cañon near Station 125.
Conocoryphe sp.? *Dikelocephalus* sp.? *Bathyurus* two sp.? *Obolella* sp.? *Discina* sp.?	Station 133, between Marsh and Cottonwood Creeks, north of Cache Valley.
Bathyurus sp.? *Hyolithes* sp.? *Acrotreta.* sp.? *Discina* sp.?	Mouth of Weston Creek Cañon on west side of the Cache Valley, at the south end of the northern portion of Malade Range, near station 130.
Orthis sp.?	Head of Station Creek, west of Bear River Range.

CARBONIFEROUS.

In the eastern and middle portions of the district the Carboniferous formation occupies a prominent and important position, the outcrops representing the important ranges, into whose structure they largely enter, sometimes making up whole ranges. They are the lowest rocks exposed in the Wyoming and Salt River Ranges. In the Bear River Range the Carboniferous limestones overlie conformably the Silurian, and we do not have the entire upward extension of the beds shown. I shall now briefly recapitulate the most important exposures of the Carboniferous.

Labarge Mountain.—At this locality we have two isolated masses of Carboniferous rocks. The most prominent was named after the stream just south of it and is a monoclinal ridge surrounded by Tertiary strata. There are between 400 and 500 feet of limestones exposed on the eastern face of the mountain, and a few indistinct fossils of Carboniferous aspect were seen in the beds on the summit. Whether this mountain and the northern smaller mass are the remnants of an anticlinal, or whether they

represent a line of uplift with a fault along its eastern side, could not be positively determined. I am, however, inclined to believe the former, and that they were islands in the Tertiary lake.

Thompson Plateau.—This area of Carboniferous lies west of the two island-like areas just described, and like them has westward-dipping limestones. At the south end there may, however, be dips in the opposite direction. This plateau is directly on the line of elevation of Meridian Ridge and the line of the fold continuing northward from Piney Creek. I am inclined to think there is faulting along the east edge of the plateau, but it may be that this area only represents a higher portion of the fold, in which erosion has been greater, so that the eastern side of the anticlinal has been entirely removed. To determine which is the correct view the southern end of the plateau will have to be more thoroughly investigated, and its connection with the Meridian Ridge determined. There may be a synclinal between the south end of the plateau and Labarge Mountain. At the north end the Wahsatch beds come up over the limestones.

Wyoming Range.—This range continues northward from Piney Creek, and is composed of limestones and a few bands of quartzites, in which no fossils older than Carboniferous were found by us. The eastern face of the range presents a bluff of these limestones, which dip to the westward at every point where this face of the range was seen. No detailed section was made of the entire series in the range, but there must be a thickness of from 5,000 to 6,000 feet of beds. Crossing the range from east to west, we find the centre of the mountains occupied by a shallow synclinal depression, which is best seen in the Triassic rocks north of Station 55. On the western slopes, beds of the Jura-Trias outcrop, and beyond them probable Cretaceous, all conformable to the Carboniferous. This fixes the age of the mountains as Post-Cretaceous. Along the east edge of the mountains the upper limestones of the bluff are from 2,000 to 3,000 feet above the sandstones that outcrop at the base. The latter have been referred to the Laramie Group, and they dip to the westward abutting against the westward-dipping Carboniferous. We have here, therefore, an immense displacement, which exists along the entire front of the range. The line of the fault is very irregular, curving to the westward at a number of places so that bays of the more modern rocks extend into the range. At first I thought the range was the shore line against which these beds were deposited, but at no point along the range did the Laramie sandstones show any evidence of their deposition in close proximity to the shore line. The formation of this fault and the folding observed east of the range and in its central portion were all probably contemporaneous, and should be referred to early Tertiary time. When the Wahsatch conglomerates were formed the Wyoming Range formed a part of the western shore of the lake.

Salt River Range.—This, which is also mainly a Carboniferous range, presents along its eastern face a fault like the fault of the Wyoming Range, with the downthrow also on the east. It was not accurately measured, but it is fully as great in its extent. Its southern extension is perhaps to be found in the fault along the east side of the Absaroka Ridge, which is similar though not so great in amount. In the latter place the Fox Hills Cretaceous abuts against the Carboniferous.

The structure of the Salt River Range is so complicated that the reader will have to refer to the detailed description in a preceding chapter. Suffice it to say here that there are a number of interesting folds which at the southern end of the range involve the Jurassic and Cretaceous? rocks as well as Carboniferous. The Carboniferous of the

ranges, appears from the few sections made, to be composed mainly of massive blue limestones, with which a few bands of quartzite are interlaminated.

Near Station 56 and southward, overlying conformably undoubted Carboniferous strata, a series of rather shaly and somewhat arenaceous beds was observed, which in the field were referred to the Upper Carboniferous, as they were in position beneath red sandstones considered to be of Triassic age. An investigation by Professor White of the few fossil remains from them indicates their Triassic? age.

South of the Salt River Range a comparatively low Carboniferous range extends to Twin Creek from the head of Smith's Fork of the Bear, on the east side of Ham's Fork of Green River. Neither these rocks nor those of the Sublette Range, referable to the Carboniferous, were sufficiently studied to develop the details of their occurrence. They form an anticlinal.

Preuss Range.—In this interesting range the Carboniferous rocks, consisting of massive limestones, showing in several sharp folds, yielded a number of their characteristic fossils. North of the range, at Station 65, the upper portion of the formation consisted of a white quartzite, siliceous limestone, and laminated blue limestones, above which were arenaceous strata with Triassic? fossils.

Bear River Range.—In the central portion of the Bear River Mountains massive limestones form an important part of the range. They have a thickness of 5,000+ feet. In the upper part they become somewhat siliceous. These beds form the Wahsatch Group of the Fortieth Parallel Survey, the base of which has been referred to the Devonian by the geologists of that survey.

No Devonian fossils were obtained by us, and I have therefore not been able to separate the formation nor to color it on the map as distinct from the Carboniferous.

Portneuf Range and Soda Springs Hills.—The northern portion of the Portneuf Range is probably almost entirely Carboniferous in its southern extension. A quartzite lies at the base of the section here, and the central portions consist of dark-blue, gray, and lighter colored limestone, with quartzites and siliceous limestones on top.

In the Soda Springs Hills, as far as seen, the Carboniferous outcrops are similar to those already described. The limestones contained an abundance of their characteristic fossils.

Section of Carboniferous.	
1. Rather compact, heavily-bedded limestones, with a few quartzitic layers at the base in the Wyoming and Salt River Ranges. Massive blue and gray limestone, with laminated layers at the base in the Bear River Range. Blue dove-colored and reddish weathering limestones in Portneuf Range. Thickness, about 5,000 feet.	Thickness, 6,000+ feet.
2. Quartzites in Portneuf Range, and in Wyoming and Salt River Mountains quartzite with overlying dark-blue laminated limestones in Station 65 ridge.	

This general section is based on the following detailed section: Nos. 9, 14, 15, 16, 17, 19, 20, 30, and 31.

I did not recognize any beds as of Permo-Carboniferous age, nor could I separate the Sub-Carboniferous from the Coal Measure limestones, as none of the fossils found were typical of the lower division of the formation.

Organic contents.

I have already intimated that a portion of the beds referred by me to the Carboniferous may be Devonian or Silurian, but all the determinable fossils collected are Carboniferous in their facies. Many of them are undoubtedly referable to the Coal Measures, which in our district consist almost entirely of limestones. The forms of some of the subdivisions of the Carboniferous are so apt to be vertically distributed throughout the others that the division is of little use except on lithological grounds, and our sections are too general to do that in the district under consideration. A list of fossils from the west side of Soda Spring Hills, collected in 1871, is given in a preceding chapter.

The following is a list of Carboniferous fossils collected in the district during the season, and kindly identified for me by Professor White:

List of Carboniferous fossils.

Zaphrentis sp.? *Productus* sp.? *Hemipronites* sp.?	Labarge Mountain, Stations 19 and 20.
Zaphrentis sp.?	Station 25, west of Fontenelle Cañon.
Productus sp.?	Coketown Butte, north of Smith's Fork of Bear.
Zaphrentis sp.?	Station 47, South of Piney Creek.
Archimedes sp.? *Crinoidal* stems. *Corals* indistinct.	Station 48, between the heads of Piney Creek.
Spirifer sp.?	In bowlders from conglomerates of the Wahsatch Group, north of Bitterroot Creek.
Spirifer striatus. *Spirifer* sp.? *Spirifer* (*Martinia*) *planoconvexus.* *Zaphrentis* sp.? *Glauconome* sp.? *Rhombopora* sp.? *Chonetes platynota.* *Syringopora* sp.? *Fenestella* sp.? *Crinoid columns.*	Virginia Peak, near the north end of the Salt River Range, on the east side.
Productus multistriatus.	McDougal's Pass, at head of Sickle Creek.
Hemipronites crenistria. *Spirifer* sp.? *Euomphalus* sp.? *Platycrinus* sp.? *Zaphrentis* sp.? *Murchisonia* sp.? *Synocladia* sp.? *Productus* sp.? *Proetus* sp.? *Streptorynchus* sp.? *Ptilodyctia* sp.?	Station No. 57, at the north end of the Salt River Range, west side.

Productus costatus. *Spirifer rockymontanus.* *Crinoidal* stems.	Station No. 82, on east side of the Upper Portneuf Valley.
Rhombopora lepidodendroides. *Hemipronites crenistria.* *Productus* sp.?	Ridge southeast of East Fork of Blackfoot River.
Spirifer rockymontanus. *Athyci subtilita.* *Zaphrentis* sp.? *Productus* sp.? *Crinoidal* stems.	Station No. 110, south of Bear Lake, on east side of valley.
Zaphrentis sp.? Crinoidal stems.	Station 114 in Bear River Range, west of Bloomington.
Leptopora sp.? *Rhynchonella* sp.? *Crinoidal* stems.	Station No. 125, at Forks of Logan River, in cañon.
Productus sp.? *Rhynchonella pustulosa.* *Rhynchonella rockymontana.* *Enomphalus* sp.? *Spirifer rockymontanus.* *Spirifer striatus.* *Spirifer* (*Martinia*) sp.? *Athyris* (*Spirigera*) *subtilita.?*	Middle of Logan Cañon.
Zaphrentis sp.? *Fenestella* sp.? *Rhombopora lepidodendroides.* *Productus prattenianus.* *Rhynchonella uta.* *Spirifer striatus.*	Eastern slopes of Station 136, on west side of Malade Valley.
Zaphrentis sp.? *Enomphalus* sp.? *Aulopora* sp.? *Productus costatus.*	West side of the Malade Valley, south of Samaria.
Enomphalus luxus. *Productus semirecticulatus.* *Spirifer rockymontanus.* *Spirifer* (*Martinia*) *planoconvexa.*	Ridge leading to Station 137, on west side of Malade Valley.

PALÆOZOIC OROGRAPHY.

It is manifestly impossible to enter into any extended generalizations from the few facts gathered during the hasty examination of a district of 13,000 square miles in one season. There are, however, a few points to which I deem it necessary to call attention.

First. The sections of Palæozoic rocks render it evident that the sediments were deposited in a deep sea. The Silurian and Carboniferous ages were eminently limestone-making ages in our district, and the western, northern, and southern shores of the Palæozoic sea were probably far beyond the limits of our district. The Wind River Mountains, as well as the Rocky Mountains, of Colorado and their northern extension, rose above the Palæozoic sea, and their western slopes probaby formed a portion of the eastern shore line.

Second. The Palæozoic sediments show no unconformability in our dis-

trict. There was, therefore, no disturbance during the period within the limits of the area studied by us during the season of 1877. The evidence also points to a successive subsidence, which corresponds to what was observed in Colorado.*

Along the western edge of the Wind River Mountains we find that Tertiary strata rest on the Archæan rocks, and Mr. St. John informs me that in the Teton Mountains we do not find the chloritic rocks of the Cambrian interposed between the Potsdam sandstone and the Archæan nucleus of the range.

It appears, therefore, that in Cambrian time the shore line was a long distance west of the Rocky Mountain chain. The upper part of the Carboniferous indicates a change from the deep seas to shallower seas, which continue through the earlier portion of the Mesozoic time. The faulting of the Palæozoic rocks of the eastern ranges is Post-Cretaceous or Early Tertiary in its occurrence, for we find the Jura-Trias and Cretaceous conformable to the underlying Carboniferous.

MESOZOIC ROCKS.

The Mesozoic rocks of the district are particularly interesting, not only in their lithological structure, but in their faunal characteristics, especially as regards the portion referred to the Triassic. They occur in long, narrow zones, extending north and south along the edges of the Palæozoic outcrops in the mountains; and east of the mountains, where the uplift has not been so high nor the erosion so great, we find them folded and underlying Tertiary strata, with which they are markedly uncomformable. In the region of the Blackfoot the Mesozoic rocks have been subjected to a complicated folding, and form important ranges, which extend to the northward into Mr. St. John's district. The sequence of the strata shows a progress from limestones to sandstones. The Triassic is an alternation of limestones and arenaceous shales, with red sandstone at the top. In the Jurassic we have limestones and shales, while in the Cretaceous the limestones are few, the progress being from argillaceous and calcareous shales to siliceous sandstones, which form heavy beds in the Fox Hills Group.

The Cretaceous formation is doubtless present above the Jurassic in most parts of the district, but the data obtained are meager. Fox Hills fossils were obtained at two localities, but the lower divisions were not positively recognized.

It has been frequently stated of late that the separation of the Trias from the Jura is, at present, a matter of difficulty in the West, from the fact that the forms supposed to be characteristic of the Jurassic have been found in the lower rocks referable to the Trias. My collections from the base of the Trias during the season of 1877 appear to point to the same state of confusion in the distribution of the Triassic and Jurassic fauna, although there are indications that data may yet be found which will warrant the definite separation of the Trias from the Jura. Either there is no line to be drawn between the two periods in this portion of the country, or, as is more probable, we are not yet familiar enough with the organic remains of the periods to say what are the characteristic faunæ. The period of sedimentation appears to be uninterrupted from one period to the other, with the strata of both similar, and it is scarcely to be wondered that some forms of the animal life of the periods should also be continuous. I, therefore, still use the term

* Report U. S. Geol. Survey for 1874, 1875, pp. 68, 69.

Jura-Trias, making the divison of the formations in the section partly on lithological grounds.

JURA-TRIAS.

Immediately overlying the Carboniferous limestones in the Salt River Range, and in the ridge of Station 66, is a series of alternating arenaceous beds and laminated limestones. They are conformable to the Carboniferous, and, at first, were referred to the Permian division of that age, as above them was a series of red sandstones and shales, which were without hesitation referred to the Trias. The examination of their organic contents, however, by Dr. White indicates them to be of Triassic age. With these are Jurassic forms. Above the red sandstones are blue limestones, followed by shales and quartzites, in which undoubted Jurassic fossils are numerous. The paleontological question suggested by the mingling of Jurassic and Triassic forms will be discussed elsewhere by Dr. White.

TRIASSIC.—The red sandstones and the beds lying between them and the Carboniferous limestones I shall treat under this head, dividing them into the two groups, which I call the "Red Beds" and the "Meekoceras Beds"; the latter is named from the characteristic fossils, a new genus, of which three species were collected.

The Triassic rocks are found entering conformably into the folds which have resulted in the formation of the various ranges of our district. I shall now briefly recapitulate the principal occurrences of the rocks.

Green River Basin.—On the west edge of the Green River Basin the fold that marks its western boundary is rarely cut through so as to expose the Trias. At Fontenelle Cañon, below the Jurassic beds, red quartzites outcrop. These were referred to the Red Beds, as was also the outcrop of red sandstones at the mouth of the cañon of Ham's Fork (p. 534.) Farther north a quartzite referred doubtfully to the Trias is occasionally seen in some of the cañons cut by the streams on their way from Meridianal Valley to the Green River Basin. All these outcrops are limited.

Wyoming Range.—On the summit of the Wyoming Range an area of Red Beds occupies the synclinal depression which extends northward from Station 55. At the latter point was made the only detailed section of the Red Beds. It is given in Section No. 10, and shows them to consist mainly of dark red quartzites, with shaly and calcareous layers coming in towards the base. The total thickness here is a thousand feet or more. The "Meekoceras Beds" probably show below, but the section could not be carried through them.

Along the western side of the range the "Red Beds" show in the valley of John Day's River, forming low hogbacks. The Triassic rocks of the Wyoming Range are probably the northern continuation of those seen in Fontenelle Cañon. The greater elevation here and the consequent erosion have removed the overlying Jurassic, which in Meridian Ridge conceals the Trias.

Salt River Range.—In the Salt River Range we find both groups of the Trias entering into the complicated folds which enter into its structure. The outcrops of Triassic do not appear to extend north of Glacier Creek, and for the details of their occurrence in the region of Stations 56 and 58, the reader will have to refer to the description of the Salt River Range given in Chapter IV. At Station 56, above the Carboniferous limestones containing *Productus multistriatus*, is a series of arenaceous and calcareous beds, which, when first seen, were referred to the upper division of the Carboniferous. They contained a few fossils, which have

been identified by Prof. C. A. White as Triassic (?). Their resemblance to beds at Station 66 was apparent, and they were considered to be of the same age while we were in the field.

Blackfoot Basin.—In this region the Triassic beds are generally concealed by the overlying Jurassic limestones and shales. At Station 66, however, and in several of the ridges in the immediate neighborhood, as at Station 70 and various points in the northern spurs of the Preuss Range, we have the lower division showing.

Bear Lake Plateau.—Towards the northern end of the Bear Lake Plateau the Triassic red sandstones appear in folds under the almost horizontal layers of the Wahsatch Group. These beds, with the overlying Jurassic, continue northward to the Preuss Range.

Sublette Range.—The eastern slopes of the Sublette Range are almost entirely of Jurassic rocks. On the west, however, the Red Beds show. The lower group does not appear as far as noted by us.

JURASSIC.—The localities given for the Triassic might be given also as Jurassic localities, and I shall therefore not repeat them here, but refer the reader to the preceding chapters.

The Jurassic strata are conformable to the underlying Red Beds. I have divided them into two groups, which I have named after the fossils that appear to be characteristic of them, at least as far as the district is concerned.

The lower group consists mainly of blue and gray limestones which become shaly towards the top of the section. *Pentacrinus asteriscus* appears to range through the limestones from top to bottom. The upper group is mainly arenaceous, and at the locality of the best section, contained *Belemnites densus*, from which I have named the group, although it is probable that *Belemnites* extends down in the formation, and will be found associated with *Pentacrinus*.

The following is the general section of the Jura-Trias of the district examined by us:

General section in Southeast Idaho and Western Wyoming.

JURA TRIAS.	JURASSIC.	BELEMNITES BEDS.	4. Red and gray shales with green sandstones, and arenaceous limestones at the upper portion of the section, capped by a quartzite that is probably the base of the Cretaceous.	700 feet.	1,500 feet.	Sections Nos. 11 and 25.
		PENTACRINUS BEDS.	3. Laminated limestones, blue at base, passing into gray at top, succeeded above by grayish calcareous shales; many of the layers are probably arenaceous.	800 feet.		
		RED BEDS.	2. Red quartzitic sandstones with shaly arenaceous and calcareous layers at the base of the section. These are probably the equivalents of the typical Red Beds of the Eastern Rocky Mountain region.	1,000 + feet.	4,000 + feet.	Section No. 10
	TRIASSIC?	MEEKOCERAS BEDS.	1. Alternations of reddish and greenish sandstones and arenaceous and calcareous shales with blue and gray laminated limestones. These beds are fossiliferous at four horizons, containing species of a new Triassic? genus by Professor Hyatt, together with forms that have been heretofore considered as of Jurassic age.	3,000 + feet.		Section No. 19.

This general section, as I have already indicated, has been compiled from the detailed sections given in preceding portions of the report. The numbers of these sections are given in the right-hand column of the table.

Section No. 11, in John Day's Valley, begins just at the top of the "Red Beds." Of the latter the best section was made at Station 55. (Section No. 10.)

The section of Station No. 66 (Section No. 19) is the section of the Meekoceras Beds, and I am of the opinion that it lies immediately below the Red Beds. In descending the ridge leading southwest from Station 66, the last dips seen are towards the southwest, but the timber soon becomes dense and obscures the outcrops. After passing through the timber and coming out in the Blackfoot Valley, red sandstones, in all respects like those in John Day's Valley and the Salt River Range, are noted with a northeastern dip. It is evident, therefore, that the timber covers a synclinal axis, and the red sandstones probably outcrop with a southwest dip somewhere between Station 66 and the northeasterly dipping outcrop on the Blackfoot.

Again, in the Salt River Range below the red sandstones is a series of grayish calcareous and arenaceous beds, resembling those of section No. 19 at Station 66. These beds also contain *Aviculopecten pealei* and *Gervillia*, which occur in section No. 19.

The beds therefore appear to be lithologically and palæontologically identical, and also occupy the same position stratigraphically, and I have no hesitation in connecting the sections as I have done in the general section.

The limestones, called the "Pentacrinus Beds," were so named because *Pentacrinus asteriscus* appeared to be a characteristic fossil of the beds wherever they were seen.

The only fossils from the "Belemnites Beds" were obtained in John Day's Valley, and this name was given provisionally, although it is probable that *Belemnites densus* will be found to range down through the section in other localities, when a more careful investigation shall be made.

The name "Red Beds" has been retained for the red sandstones because they are supposed to be equivalent to the "Red Beds" of the Eastern Rocky Mountain region in Colorado and adjacent regions.

Organic contents.

The fossils from No. 1 of the section have been described by Professor White in Bulletin of the Survey, Vol. V, No. 1, pp. 105–117. The list is as follows:

Meekoceras gracilitatis.
Meekoceras mushbachanus.
Meekoceras aplanatum.
Arcestes ? cirratus.
Arcestes ? two species.
Terebratula semisimplex.
Terebratula augusta.
Aviculopecten idahoensis.
Aviculopecten pealei.
Aviculopecten altus.
Eumicrotis curta.

Dr. White says:

Among the exposures of Jura-Trias strata in the district here indicated (and they are numerous and comparatively small in consequence of the great disturbance which they, together with their associated strata, have suffered), there are three localities which are especially interesting, because the strata there exposed contain not only a number of new forms, but because some of the types in which those forms are expressed are such as in Europe are regarded as characteristic of the Trias.

Professor Hyatt proposes one new genus, which has not only important and significant relations with other genera, but the fact is an interesting one that with its first and only discovery three strictly conforming, but well-differentiated species, were found associated together, indicating thereby the permanent establishment of that generic form.

According to European standards, the Cephalopods here described are unquestionably of Triassic types, and, as pointed out by Professor Hyatt, * * * they have more resemblance to certain Cephalopods of the Muschelkalk of Europe than to any other. This is an interesting and somewhat unexpected circumstance, since the only other Cephalopod forms from strata of the Western Territories which have been assigned to the Trias as distinct from the Jura have been regarded as especially representing the horizon of the Saint Cassian Aussee and Halldstadt deposits of Europe.

The fossils here referred to by Dr. White are described by Professor Meek in Vol. IV Report U. S. Geol. Exploration of Fortieth Parallel. They are from the Star Peak Group of Western Nevada.*

King, in speaking of this group, which he calls the Alpine Star Peak Trias, says:

It will be remembered that the Trias east of the Wahsatch is also stratigraphically divided into two prominent parts of nearly equal volume; the lower red-beds, which contain little or no limestone, and but few isolated beds of gypsum, and the Upper Red Bed, which are characterized by occasional limestone seams of no great volume, and frequent occurrences of gypsum. These two Triassic seas, separated by a wide area of continental land, differ from each other in a manner which renders correlation next to impossible. If there is any correlation between the beds of the two series, it would seem probable that the Koipato is the equivalent of the Lower Red Beds of the eastern sea, and that the overlying Star Peak Group may be the equivalent of the Upper Red Beds, the two being characterized by intercalations of limestone.†

Our district is intermediate between the district here referred to by King and the eastern seas mentioned by him, and it is difficult to correlate the sections lithologically. We have, however, calcareous layers in the Red Beds (No. 2 of the section), and if the fossils from the Star Peak Group are Upper Trias, and those from No. 1 of our section are the equivalent of the fossils of the Muschelkalk of Europe, we may, perhaps, indicate the correlation as follows:

King's Section.		Section in Southeast Idaho, &c.
Star Peak Group	=	Red Beds.
Koipato Group	=	Meekoceras Beds.

Whether the Meekoceras Beds should be considered as of Lower or Middle Trias cannot, of course, be stated as yet. The Nevada section has a much greater thickness than our section, which is, however, greater than that of the Colorado section.

It is possible that a portion of the beds referred to the Upper Division of the Carboniferous in some portions of the West may yet be found to be in part at least equivalent of the Meekoceras Beds. In settling some of these doubtful questions, there is scarcely any portion of the West that will afford a better ground for study than the district rapidly gone over by us in 1877.

The following is a complete list of the Jura Trias fossils collected by us and identified by Professor White:

* U. S. Geol. Exploration of the 40th Parallel, Vol. II, chapter V; Vol. I, p. 269.
†*Ibid.*, Vol. I, p. 270.

List of Jura Trias fossils.

Pentacrinus asteriscus. *Camptonectes bellistriatus.* *Ostrea strigilecula.* *Ostrea* sp.? *Trigonia* sp.? *Mytilus* sp.? *Myalina* sp.? *Volsella* sp.?	Meridian Ridge south of cañon of Fontenelle Creek.
Eumicrotis curta? *Myalina whitei?* *Aviculopecten idahoensis.* *Myacites* sp.? *Volsella* sp.?	West side of Rock Creek, branch of Twin Creek, east of Bear River.
Aviculopecten idahoensis? *Aviculopecten* sp.? *Lingula brevirostris.* *Ostrea* sp.? *Myacites* sp.? *Eumicrotis curta.*	North side of Smith's Fork Valley above the mouth, east of Bear River Valley.
Pentacrinus asteriscus. *Camptonectes bellistriatus.*	Sublette Range east of Station 38.
Camptonectes stygius?	East of Smith's Fork of Bear River.
Pentacrinus asteriscus. *Ostrea strigilecula.* *Tancredia* sp.? Undetermined *conchifers.* Undetermined *gasteropods.*	Near the mouth of the lake branch of Smith's Fork of Bear River.
Pentacrinus asteriscus? *Neritina* sp.?	North side of Lake Creek.
Pentacrinus asteriscus. *Camptonectes bellistriatus.* *Trigonia* sp.? *Myascites* sp.?	Near mouth of McDougal's Creek, lower part of section No. 11.
Belemnites densus. *Aviculopecten Idahoensis.* *Gryphæa* sp.? Undetermined bivalves.	Near mouth of McDougal's Creek, upper part of section No. 11.
Ostrea strigilecula. Undetermined forms.	Stations 89 and 90, Aspen Ridge, east of Soda Springs.
Meekoceras aplanatum.* *Meekoceras gracilitatis.* *Aviculopecten altus.*	On Middle Creek, one of the southern branches of the Blackfoot River.

* New genus established by Prof. A. Hyatt.

Meekoceras gracilitatis. *Meekoceras mushbachanus.* *Arcestes cirratus.* *Arcestes* sp.? *Arcestes* sp.? *Aviculopecten pealei.* Undetermined *conchifers.* *Eumicrotis curta.* Undetermined *conchifers.*	Ridge north of Station 66, south of John Gray's Lake.
Aviculopecten idahoensis. *Eumicrotis curta.*	Station 66, south of John Gray's Lake.
Terebratula augusta. *Terebratula semisimplex.* *Aviculopecten idahoensis.* Undetermined *conchifers.* *Gervillia* sp.?	Ridge south of Station 66.
Aviculopecten idahoensis. *Aviculopecten rectus.* *Terebratula augusta.*	Station 70, west of Blackfoot River.
Aviculopecten pealei. *Gervillia* sp.?	Ridge north of Station 56, Salt River Range.
Aviculopecten idahoensis? *Eumicrotis curta.*	Near Station 100, north end of Bear Lake Plateau.
Ostrea strigilecula?	West of Station 108.

Pentacrinus asteriscus was found nowhere associated with *Meekoceras* or *Eumicrotis*, and the latter was never by us found in the strata above the Red Beds. The following, as will be seen from the list just given, were the associated fossils with *Pentacrinus asteriscus:*

Camptonectes bellistriatus.
Ostrea strigilecula.
Trigonia sp.?
Tancredia sp.?
Volsella sp.?
Myalina sp.?
Myacites sp.?
Neritina sp.?
Undetermined *conchifers.*
Undetermined *gasteropods.*

These are all Jurassic forms; and I believe the only instance in which *P. asteriscus* has been found associated with Triassic forms is the one mentioned in the reports of the Fortieth Parallel Survey,* in which it is stated that it was found associated with what are regarded as unmistakable Alpine Trias fossils and also a spirifera, a palæozoic type. Mr. Emmons says:† "It should be stated also that these disks of *Pentacrinus* found in the Dun Glen limestone vary somewhat from the type specimens, and are all of larger size, reaching one-fourth of an inch in diameter, while those of Jurassic age scarcely reach one-fifth of an inch. Pro-

* Descriptive Geology, Vol. II, p. 711; Systematic Geology, Vol. I, pp. 279, 280.
† Descriptive Geology, Vol. II, p. 711.

fessor Whitfield suggests that the Dun Glen variety may possibly be a new species."

Eumicrotis curta was not found associated with *Pentacrinus* at any point in our district, but at several localities where the section was obscure it was found with—

Aviculopecten Idahoensis ?
Lingula brevirostris.
Myalina sp. ?
Myacites sp. ?

The beds, however, were above the Red Beds, but I was unable to determine their relations to the Pentacrinus beds.

In other areas *Eumicrotis curta* has been found associated with Jurassic fossils. In the areas surveyed by the Fortieth Parallel Survey it occurs with—

Belemnites.
Gryphæa.

In our district, we have seen that it occurs associated with the Triassic? fossils in the "Meekoceras beds" which proves, as Dr. White has said,* a great vertical range for the species. He also remarks that *Terebratula augusta* (Hall and Whitfield) has been considered by the authors as a Jurassic species.

The Cephalopods of the "Meekoceras beds," described by Dr. White, are, he says, unquestionably Triassic, according to European standards, and resemble Cephalopods of the Muschelkalk of Europe.

The only other Triassic Cephalopods from the West are those obtained by the Fortieth Parallel Survey, from the Star Peak Group in Nevada, and they have been considered the faunal equivalents of the St. Cassian and Hallstadt beds of the Austrian Alps.

The Star Peak Group, as we have seen, is referred by King to the Upper Trias, while the fossils from our district appear to indicate Middle Trias as the age of the beds from which they were obtained. The fossiliferous rocks have, however, not been closely enough studied as yet to predicate their exact horizon, and we cannot, therefore, be too cautious in speaking of their age.

There are numerous circumstances that appear to indicate that in the Jura-Trias, as in other formations, there is what may be called a plane of paleontological indefiniteness at either end of the formation. This has often been stated by Dr. White, and as he has remarked, when the deposition of sediments is continuous from one formation to another, it is not strange that forms of life should continue uninterruptedly from one to the other. It is not strange, therefore, that we should find, as in New Mexico,† Triassic plants at the top of the Jurassic, and, as in our district and at many other localities, Jurassic invertebrates at the base of the Trias, and as in Nevada, Palæozoic types continuing into the lower Mesozoic. The advisability, therefore, of retaining the name of Jura-Trias for the present is obvious. With the accumulation of data many of the points that are now obscure will assume the certainty of facts.

To recapitulate briefly, the investigations of the season of 1877 indicate—

1. The lithological separation of the Jura-Trias of Southeastern Idaho

* Bulletin U. S. Geograph. and Geol. Survey, Vol. V, No. 1, p.—.
† See Report U. S. Geol. Survey for 1875–1876, pp. 84–87.

and Western Wyoming into three divisions, the upper and lower ones mainly calcareous and the middle mainly siliceous.

2. The discovery in the lower group of a new Triassic genus of Cephalopods, named by Prof. A. Hyatt, of which three species have been described by Dr. C. A. White.

3. The association with these Cephalopods, of forms that have heretofore been considered as Jurassic.

4. The absence of fossils in the "Red Beds," or middle group.

5. In the limestones above the "Red Beds" the presence of undoubted Jurassic forms, two of which, perhaps, range through the series down into the "Meekoceras Beds," or lower group.

The latter part of these remarks have been published already in the Bulletin of the Survey, Vol. V, No. 1, in almost the same shape as here.

CRETACEOUS.

The only group of the Cretaceous from which fossils were obtained was the Fox Hills Group, which at two localities in the Fontenelle Hogbacks yielded the following:

Ostrea soleniscus.
Ostrea sp.?
Trapezium sp.?
Inoceramus sp.?

The sandstones forming this group are treated of in Chapter III.

It is probable that the entire Cretaceous series is present beneath the Fox Hills Group, but as we did not find any paleontological proof, I shall content myself by referring the reader to the detailed descriptions already given.

In the valley of John Day's River, at the top of the Jurassic section, is a quartzite, which has been doubtfully considered as the Dakota sandstone. Above it is a series of arenaceous beds, some 3,000 feet in thickness. We had no good exposure of these beds, but they have been thought to represent the Cretaceous formation, although no organic remains were obtained from them.

A similar set of beds was seen above the Jurassic section on the lake branch of Smith's Fork of Bear River. Here the softness of the strata was the cause of their almost total concealment.

Above them is a conglomerate, which is succeeded by greenish laminated sandstones, which contain lignitic layers. These upper beds have been considered as of Laramie age.

In the valley of Smith's Fork, south of this locality near the bend, there appears to be no room for the Cretaceous between the Jurassic and the Laramie, and while in the field I was inclined to think there might be a gap between them, caused by subsidence of the surface during the deposition of the Cretaceous. I shall, however, have to leave the consideration of the Cretaceous until it is more certainly identified and correlated with the well-known Cretaceous sections.

The formations thus referred to the Cretaceous are confined to the eastern half of the district. From the Bear River Range and the Preuss Range westward they are absent. Whether they were ever present, I cannot say.

POST-CRETACEOUS.

It is unnecessary to enter at this place into a discussion as to the origin of the term Post-Cretaceous, as used by Dr. White and the other

members of the survey. The group of strata referred to the formation is the Laramie Group, in regard to the age of which so much has been written. The transitional character of the beds was long ago noted by Dr. Hayden and other writers. As long as the evidence presented by the various organic contents is conflicting, it seems best to retain the term Post-Cretaceous.

The areas from which fossils characteristic of the group were obtained in our district may now be briefly enumerated.

Green River Basin.—Along the eastern foot of the Wyoming Range, between it and meridian fold, that marks the rim of the Green River Basin, there is a series of greenish-gray sandstones with shaly bands, which rest on the beds that I have referred to the Cretaceous. The ends of these sandstones, dipping westward, abut against the westward-dipping limestones of the range. The line of junction marks the line of an immense fault. This fault is some 2,000 or 3,000 feet, the downthrow being on the east. A similar fault is seen along the east side of the Salt River Range, but whether or not there are any Laramie beds involved here I cannot say at present.

The line of junction between the Laramie beds and the Carboniferous limestones is generally obscured by *débris*. I was not able to get a good section, but there must be in the neighborhood of 4,000 feet of sandstones referable to the group along the foot of the range. It is probable, also, that the entire thickness of the group is not exposed. Following the folding and faulting which affected these beds, there was a period of erosion preceding the deposition of the Wahsatch Group. The latter is unconformable to the Laramie Group along the entire range, while the Laramie appears to be conformable to the underlying formations. At the bend of Ham's Fork there is an outcrop of sandstones, from which Laramie fossils were obtained, but there is a fault at this locality which has confused the relations of the strata, and it is not certain that the fossils obtained were in place.

The line of the fault along the eastern side of the Wyoming Range is not a straight line; but the Laramie sandstones fill bay-like recesses in the Carboniferous limestones of the range. This is especially the case in the northern portions, and led me at first to think that the range had formed a portion of the shore of the Laramie Sea; but afterwards the contact of the sandstones with the limestones was well seen, and the former were seen to have a dip to the westward against the limestones, which also dip to the westward. It was clearly seen to be a fault. The latter seems to have taken place a little after the sandstones were folded, or perhaps they were crowded against the mass of Carboniferous limestones at the time the fault occurred. The conditions here are shown in the sections of Meridian fold in Chapter III.

There was no evidence in the Laramie beds of the immediate proximity of the shore during their deposition, as there was in the beds of the Wahsatch Group.

Smith's Fork and Bear River region.—Along the east side of Bear River, between the valley and the mountains, is a comparatively low area of sandstones, which sometimes assume the character of low hog-back ridges. These sandstones are gray and greenish gray. They are folded corresponding to the folds of the older rocks. On Twin Creek they are seen below Wahsatch conglomerates, which rest on their upturned edges. Here there are layers of coal, from which unmistakable Laramie fossils were obtained. On Smith's Fork, also, a bed of coal outcrops, and from it a few forms were obtained.

North of this region, near Station 41, another fossil locality was noted,

and above the greenish and gray beds a series of red sandstones, many of them conglomeritic, were noted. These beds are seen much farther to the north, extending into Mr. St. John's district. No detailed section was made, but there must be from 6,000 to 7,000 feet of beds. It must be borne in mind that the line between the Laramie Group and the Cretaceous has not yet been drawn in this region. I shall, therefore, not attempt to give any general section of the formation at present. The fossils next found below the Laramie were Jurassic; but there was plenty of room between the fossiliferous horizons for the entire Cretaceous series, which is probably present, although not positively recognized.

The series, from the Carboniferous up through the Jurassic and overlying beds, is perfectly conformable until we reach the Wahsatch Group, which, wherever seen, was distinctly and strikingly uncomformable.

It must be remembered that the region investigated by us was probably near the western shore line of the Wahsatch Lake, and a considerable portion of the area that was below the level of the Laramie sea became land after the deposition of the Laramie beds, or perhaps before the end of the period. The bottom of the Laramie sea appears to have been subjected to a constant and gradual subsidence, as the strata indicate their deposition in shallow waters, and the thickness attained by them must be at least 5,000 feet. The upper conglomerates in the Smith's Fork region and between Crow Creek and Beaver Creek resemble the lower beds of the Wahsatch Group, although they are firmer; probably from the fact that during the orographical disturbances that occurred after their deposition they were subjected to considerable folding and consequent lateral pressure.

The lower sandstones are similar to those of the Fox Hills Group, and as far as known the two formations are conformable. There were some indications at the lower end of Ham's Fork Cañon that the Laramie Group rested on the upturned edges of the Triassic Red Beds, but the fossils were not found in place, and other portions of the region seemed to indicate that the Laramie Group was conformable to the underlying formations.

Organic contents.

The fossils collected were from two localities in the Green River Basin and three in the Smith's Fork and Bear River region. They have all been identified by Dr. White as equivalent to those of the Laramie Group as exposed in the Bear River estuary beds.

The following is the list of these fossils collected during the season, identified by Dr. C. A. White:

List of fossils from the Laramie Group.

Corbula sp. ? Undetermined forms.	West side of Meridian fold in Meridional Valley, on Piney Creek.
Campeloma macrospira. *Corbula* sp. ? *Pyrgulifera* sp. ?*	Lower end of the cañon of Ham's Fork, east side of Oyster Ridge.

* In addition to these a fragment of a leaf of an Aralia was found.

Corbicula (*Veloritina*) *durkei.* *Membranipora?* *Rhytophorus meekii.* *Goniobasis chrysallis.* *Goniobasis chrysaloidea.* *Volsella* (*Brachydontes*) sp.? *Pyrgulifera humerosa.* *Ostrea* sp.? *Neritina* sp.?	Twin Creek, about four miles above its mouth, east of Bear River Valley.
Corbicula Veloritina durkei. *Corbula pyriformis.* *Goniobasis chrysaloidea.* *Goniobasis cleburni.* *Pyrgulifera humerosa.* *Unio vetustus.* *Ostrea* sp.?	Station 41, on Thomas Fork of Bear River, north of Sublette Range.
Unio vetustus.	North side of Smith's Fork of Bear River, 3 miles above the mouth.

MESOZOIC AND POST-CRETACEOUS OROGRAPHY.

We have seen that with the beginning of the Trias there is a change in the characters of the rocks. Instead of the massive limestones of the Carboniferous, we have a series of interlaminated sandstones and then limestones. The beds are largely detrital, and their structure points to their derivation from a land area not far distant. They indicate also the probability of a progressive subsidence, interrupted by oscillations. The continental area uplifted, according to King, at the end of the Carboniferous, is probably the source of the detrital material entering into the composition of the Triassic formation, as its eastern shore-line was west of the present Wahsatch Range. That the Post-Carboniferous uplift did not affect the area embraced in our district is proved by the perfect conformity between the Carboniferous and the Trias everywhere observed in our district. The only effect was indirect in the changing of the character of the sediments.

There is also no evidence of disturbance at the close of the Jurassic. The latter is a limestone-making period at the beginning everywhere in our district, and the change from the Trias is marked as though the period had been ushered in by a considerable subsidence. Toward the close the waters appear to have been shallower, the sediment becoming more and more arenaceous until in the Cretaceous we have shales and sandstones almost exclusively.

As already noted, the conformability extends to the top of the Laramie group, as exposed in our district. After the deposition of the latter the region was subjected to the most intense orographical disturbance. The region from the Green River Basin westward was upheaved. The Wyoming Range, the Salt River Range and the isolated mountains in the western part of the district, all owe their origin to this folding, which was accompanied by the faulting of the strata that is seen along these two ranges. The folding of Meridian Ridge was also synchronous. The Wahsatch Lake was outlined, its eastern shore being the uplifted Wind River Mountains which had probably existed as an island in Palæozoic and Mesozoic time, and its western shore the Wyoming Range and Absaroka Ridge. The Meridian Ridge and its northern extension probably at first

represented the western edge of the lake, but it soon spread so that it reached from the Wind River Mountains to the very base of the Wyoming Range and around its southern end, westward to the Bear River Range.

At first I was somewhat inclined to consider the faulting along the Wyoming and Salt River Ranges as of later date than the Post-Cretaceous fold which is seen in the ranges and the eastern outlying ridge, but resting on the eroded edges of the Laramie sandstones which enter into this fold I found Wahsatch conglomerates composed of limestone pebbles, that, without doubt, came from the main range, which must, therefore, have formed a portion of the shore-line of the lake in which the conglomerates were deposited, and from the erosion of this land area they were formed. I therefore consider the folding and faulting to have occurred at approximately the same time.

In the western portions of the district the Cretaceous and overlying rocks are absent, probably from erosion, so that we cannot now tell the westward extent of the formation. The Jurassic is seen on the eastern side of the folds which form the northern extensions of the Wahsatch Range.

The region westward from what is now the Green River Basin was lifted above the level of the sea and probably added to the land area, defined at the end of the Carboniferous, which was farther west.

I have spoken of the isolated ranges in the Blackfoot region and in the Cache Valley region. They now exist as monoclinal ranges, but evidence is not difficult to obtain that they are simply the eroded fragments of anticlinals. I am inclined to regard their age the same as that of the Wyoming and Salt River Ranges, although they appear to be much more eroded, as if they had been subjected to the erosive influences for a much longer period of time. We have seen, however, that, as far as seen, the Cretaceous formation is perfectly conformable with the Jurassic; so that there is no evidence of an upheaval within the limits of our district at the end of the Jurassic. The sediments indicate a progressive subsidence from the Jurassic through the Cretaceous.

To recapitulate briefly, the facts observed in the district seem to indicate—

1. A shallowing of the sea at the beginning of the Trias due to the rising of a land area somewhere to the westward.

2. A general subsidence throughout the Trias, with oscillations of level.

3. The ushering in of the Jurassic by a somewhat paroxysmal subsidence which considerably deepened the sea. This was probably due to a Jurassic uplift in some other portion of the continent.

4. Subsidence during the latter part of the period preceded by a period of comparative rest. The sea-bottom appears to have been raised by a succession of deposits of fragmental rocks, which then subsided gradually and successively through the latter part of the Jurassic and through the Cretaceous.

5. The continuance of the subsidence through the Post-Cretaceous and the shallowing of the sea towards its close probably by a general elevation towards the close of the period which perhaps foreshadowed the disturbance which was to take place after the deposition of its sediments was completed.

6. Intense disturbance at the end of the Post-Cretaceous (as exposed in our district) which resulted in the upheaval of the area west from what is now the Green River Basin to beyond the western line of our district. The rocks of the whole region were folded and faulted in an extraordi-

nary. In the eastern and southeastern portion of the area the Wahsatch lake was outlined.

It should be stated here that the western shore line of the Post Cretaceous has not been recognized, and that it is probable that if the peripheral portions of the Laramie Group could be observed, as Dr. White remarks, some unconformity would be seen between it and the Fox Hills Group. He says:* "There must necessarily be some unconformity between these groups in the peripheral portions of the Laramie, because, as will be shown farther on, the area upon which its waters rested was cut off from the great open sea by the elevation of portions of the bottom upon which the Fox Hills deposits were made."

The fossils from the Laramie Group in our district are equivalent to those of the Bear River estuary beds. These, Dr. White is inclined to think, are somewhat older than the fossils from the group at other localities, and he therefore thinks the Post-Cretaceous upward movement may have begun before the complete deposition of the strata composing the group.†

We have seen that after the uplift a period of enormous subaerial erosion occurred, which was precedent to the deposition of the Upper Wahsatch. It would seem to have been too great to have all been caused during the earlier Wahsatch, although doubtless part of it is to be so referred. In places the whole of the Cretaceous, Jurassic, and Triassic has been removed, exposing the Carboniferous, and even sometimes the Silurian, upon the eroded edges of which the Wahsatch conglomerates rest. It seems probable, therefore, that a portion of this erosion took place during the later portions of the Laramie period. This, taken in connection with the fossils, appears to indicate that the elevation took place before the end of the Laramie period, and that, therefore, we do not have the entire series in our district.

CENOZOIC ROCKS.

The Cenozoic areas of our district are of particular interest, but the time allotted to the preparation of this report has been too short to enter into the discussion of the various points that naturally arise when considering them. In early Cenozoic time the entire western portion of our district was a land area, while the eastern was occupied by a portion of the great lake which reached eastward and southward for many miles. Still later, the conditions appear to have been reversed, and while the eastern part was above the sea-level, in the west was a series of lakes, which continued from Tertiary to Quaternary time, and of whose late existence we have a trace in the present Great Salt Lake.

The deposits are all lacustrine, generally sandstones, but with calcareous layers at various horizons. The latest deposits are soft and friable, being generally marls and loosely aggregated sands. Over the surface of the entire district, except in the mountains, there is a thin covering of unstratified drift, which will not be further considered in this report.

TERTIARY.

In considering the early Tertiary rocks of the district, I shall use only the names of the groups, without reference to the terms Eocene or Miocene. The Salt Lake Group I shall consider as Pliocene.

* Bulletin of the U. S. Geol. and Geograph. Survey of the Territories, Vol. IV, No. 4, p. 866.

† See pp. 246, 247 of this volume.

The following is the section of the Tertiary formations:

Tertiary section.

Salt Lake Group. Pliocene.	14. Soft yellow sands and marls. 13. Gray sandstones. 12. White and light brown limestones. 11. With interlaminated shales. 10. Pea-green sands and shales. 9. Coarse conglomerates.	700+ feet.	Section, pages, 602, 605, &c.
Bridger Group.	8. Somber colored soft clays and sands, sometimes variegated near the base, but generally of a dull gray color.	1,000+ feet.	Section No. 4.
Green River Group.	7. White calcareous shales and sands, with intercalated limestones. 6. Thin fissile white shales; yellow sandstones. 5. Greenish and whitish shales and sands and limestones; yellow sandstones.		
Wahsatch Group.	4. Coarse limestone conglomerates with siliceous cement. 3. Coarse red, purple, and yellow sandstones. 2. Variegated clays and sands. 1. White sandstones.	800+ feet.	Sections Nos. 2, 3, and 26.
	Total	2,500 + ft.	

In this section I have included only the undoubted Tertiary. At no place was the Salt Lake Group seen resting on the Bridger Group, nor was the latter well shown anywhere in the district.

WAHSATCH GROUP.

After the Post-Cretaceous uplift the region of the Green River Basin was occupied by a lake which extended westward in our district to the Bear River Range. It appears that in its early stages this lake was much smaller than the area now covered by the deposits indicates, for wherever the beds referable to the period were seen, they were found resting on the upturned and much eroded edges of the older strata, which include rocks from Silurian age to the Laramie Group, and the deposits represent only the upper part of the group.

The largest areas of the Wahsatch are in the northern portion of the Green River Basin, where a large part of the surface is covered by its deposits. The overlying Green River Group in this region is mostly absent, having been eroded away. Isolated buttes, however, still remain, proving its former existence and extension over the whole region. Along the southwestern slopes of the Wind River Mountains the Wahsatch beds rest on the granitic rocks, and were evidently derived from the disintegration of the granitic rocks that farther to the eastward make up the main range. They consist of yellow, gray, and pink sands and marls, which dip from 5° to 10° from the mountains. West of Green River the character of the beds is similar to those on the east. They are generally brick-red in color and weather into picturesque bad-land forms. Along the edge of the basin they are found to be composed mainly of conglom-

erates, which contain pebbles of limestone, and which were evidently derived from the adjacent mountains. When these beds were deposited it is evident that a large part of the land had been eroded, for the Mesozoic beds must have been largely removed from the mountains.* The red character of the sediments, however, is due to the wearing down of the red Mesozoic rocks, as the conglomerates of the Wahsatch are cemented by siliceous material, the predominating color of which is red. The red color, however, is more marked farther from the mountains, where the sediments are finer.

South of Thompson's Plateau we find the Wahsatch beds resting on the Jurassic rocks of Meridian ridge, beyond which they do not extend to the westward. In this region we have only a narrow line of outcrop of the group along the east side of the ridge, as the Green River Group forms a large portion of the surface to the eastward. As the ridge declines in elevation to the southward, the variegated Wahsatch beds reach farther to the westward, resting on the Cretaceous strata which were not removed from the fold.

North of Thompson Plateau the group rests on Juarassic, Cretaceous, and Laramie beds, and isolated patches rest on the latter, close to the mountains. Nowhere along the western edge do we get the entire thickness of the group. The thickness exposed is only about 500 to 800 feet. This is due to the fact that the region of the eastern outlying fold was above the level of the lake, through the earlier portion of its existence, and a portion of its sediments were derived from the erosion of the ridge formed by this fold.

An arm of the lake in the later stage of its existence reached northward, around the southern end of Absaroka Ridge in Ham's Fork Basin. A second arm extended northward in the region of Bear Lake and the Bear Lake Plateau. This arm was separated from the first by a long narrow peninsula, which now forms the range between Bear River Valley and Ham's Fork Basin. During the early stages of the lake this was probably a Mesozoic Range, but the rocks of that age were largely removed by the time the subsidence had carried it down almost to the level of the lake. In the Green River epoch it was probably under water. The Wahsatch Group, resting on its eastern flanks, is on the Carboniferous, and is not very thick. On the Bear Lake Plateau the thickness is greater, especially toward the west, and on the eastern flanks of the Bear River Range it is still greater; it increases also to the southward until it is several thousand feet in thickness. In the Bear River Plateau it rests on Palæozoic and Mesozoic rocks, which are folded and eroded, and along the Bear River Range the underlying rocks are Silurian quartzites. At Twin Creek, near our south line east of Bear River Valley, it rests on Laramie sandstones; the latter dip 40° or 45° to the westward and the Wahsatch 5° to the eastward. The unconformability is about the same along the west side of the Green River Basin. All the exposures of Wahsatch in our district are, therefore, near shore-lines of the lake.

The line that I have drawn separating the Wahsatch Group from the Green River is lithological. All the variegated beds that lie below the laminated light-colored sandstones have been referred to the Wahsatch Group and all above to the Green River.

The softness of the variegated sands and marls has caused them to weather obscurely, and wherever they rise on the slopes of a ridge it is

---

*I have already alluded to the probability of a portion of this erosion having been during the latter part of the Laramie.

difficult to identify the beds except by the color of their *débris*. Even where there is a bluffy exposure the lines of stratification are hard to follow.

Organic contents.

The materials entering into the formation of the group do not appear to be favorable to the preservation of fossils. A few fragments of bones, probably *Emys*, were obtained from the west side of Green River, above Bitterroot Creek. Pebbles of the limestone included in the conglomerates of Station *a* near Bitterroot Creek yielded a few Carboniferous forms. The fossils from Station 14 will be given under the Green River Group, as they are probably from the base of that formation.

GREEN RIVER GROUP.

The change from the sediments I have included under the Wahsatch Group to those I shall now take up is a marked one. Resting on the soft variegated beds is a series of light-colored sandstones which are followed above by calcareous layers and fissile shales.

The area between Green River and the Big Sandy is covered with the Green River Group until the northern portion of the basin is reached. North of the New Fork it is present only as cappings of the mesas that stand between the streams. Along the east side of the Green, from New Fork southward, the Green River shales and sandstones form bluffs several hundred feet in height. On the west side of the river above La Barge Creek the group is present only in isolated mesas. South of that stream, however, it is the surface formation rising from Green River to the westward and breaking off in bluffs that face Meridian Ridge. Whenever seen, the group rests conformably on the Wahsatch. It is seen dipping with the latter where it rises on Meridian Ridge and in the Ham's Fork Plateau, but when upturned it appears to have been very easily eroded, so that it generally ends in a bluff face just east of the steeper inclination. This often makes it resemble an unconformability; but it is only apparent, for the Wahsatch beds are always seen in position beneath the Green River Group, dipping in the same direction and at the same angle. As we recede from the line of greatest elevation the angle decreases, and that portion of the Green River Group which was most inclined has been removed.

In the Ham's Fork Plateau the group forms the surface of a shallow synclinal which is so slight as to be scarcely noticed between Ham's Fork and the mountain ridge to the westward. The beds here are highly fossiliferous and contain, near the top, a layer of bituminous shale. In the Bear Lake Plateau we have, just above the variegated beds, a white sandstone which may represent a portion of the Green River Group, but it is so small that I have included it with the Wahsatch. At no point in the district have we the peripheral portions of the group, so that we cannot say whether or not there was any disturbance at the end of the period.

Organic contents.

The Green River shales are highly fossiliferous, and had yielded fossils at several localities within the limits of our district previous to our explorations. In 1873, Professor Cope found numerous remains of fishes on Fontenelle Creek and on the east side of the Green, above the mouth of La Barge Creek, and with them he found "insects and their larvæ, shells like *Pupa* and *Cyrena*, and millions of *Cypris*. The larvæ are dipterous,

some nearly an inch long, and others minute and in prodigious numbers. With them are found stems of plants, but no leaves."*

Similar fossils were found on the Big Sandy in 1873 by Professor Comstock, and invertebrate fossils were obtained from the group just south of our line on Ham's Fork.†

The best fossil locality visited by us was on Twin Creek, at the south end of the Ham's Fork Plateau. This has yielded a large number of fossil fishes that have been described by Professor Cope in the Bulletins of the Survey. Associated with the fish are large numbers of leaves and insects. Of the insects all I collected Professor Scudder thinks represent a single species described in the Canadian report for 1877, not yet published. He says, "I have not yet given these specimens of yours all the attention they require."

A few leaves were collected a few miles north of this locality. They were leaf of a new species of *Myrica*, and an involucre of *Ostrya*, new species. Of these, Professor Lesquereux says, "Both these are referable to the Upper Green River Group, which is by the plants the equivalent of the White River Group."

In connection with *Unio Haydeni*, on Ham's Fork I found fragments of what appeared to be fossilized branches. Professor Lesquereux says one of them has the pith grooved like an *Equisetum*. With these occur millions of *Cypris*.

At the mouth of the Little Sandy, in connection with invertebrate remains, I obtained fragments of broken and rolled wood, which were not determinable.

The most interesting collection from the group was that of caddis-fly cases from near Horse Creek Valley, in the Green River Basin. The following in relation to them, by Professor Scudder, is quoted from No. 2, Vol. IV, Bulletin of the Survey, pp. 542, 543:

Indusia calculosa.—In certain parts of Auvergne, France, rocks are found, which, for a thickness of sometimes two meters, are wholly made up of the remains of the cases of caddis-flies. These have been frequently mentioned by writers, and Sir Charles Lyell figures them in his Manual. Oustalet, in his recent treatise on the fossil insects of Auvergne, describes two forms,‡ one from Clermond, and the other from St. Gérand, which he distinguishes under the names *Phryganea corentina* and *P. gerandina*, principally from their difference in size and strength, and a distinction in the minute shells—species of *Paludina*—of which the cases are composed. One of them, however, probably the former, was previously named by Giebel§ *Indusia tabulata*, a generic name which it would perhaps be well to employ for the cases of extinct *Phryganidæ*, until they can reasonably be referred to particular genera.

During the past season, Dr. A. C. Peale, in his explorations under the Survey, discovered on the west side of Green River, Wyoming Territory, at the mouth of Lead Creek [*This should be Horse Creek. When the fossils were sent to Professor Scudder there was some doubt as to the name of the creek. The locality is Station* 14, *south of Horse Creek and west of Green River*], in deposits which he considers as probably belonging to the Upper Green River Group, or possibly to the lower part of the Bridger Group beds of limestone, the upper floor of which is completely covered with petrified cases of caddis-flies, all belonging to a single species, which may bear the name we have applied to it above.‖ They vary from 14 to 19^{mm} in length, from 4 to 5^{mm} in diameter at their open anterior extremity, and from 3 to 3.2^{mm} at their posterior end, the thickness of the walls being about 0.75^{mm}. As will be seen by these measurements, the cases are a little larger at their mouth, but otherwise they are cylindrical, taper with perfect regularity, and are straight, not slightly curved, as in many Phryganid cases. They are completely covered with minute, rounded, water-worn pebbles, apparently of quartz, generally subspherical or ovate, and varying from one-third to two-thirds of a milli-

* Report U. S. Geol. Survey, 1873, 1874, pp. 439, 440.

† Report on Reconnaissance of Northwestern Wyoming by W. A. Jones, 1873, p. 124.

‡ Bibl. École Haut. Études; Sc. Nat. iv, art. 7, pp. 101–102.

§ Ins. der Vorw. 269.

‖ I have since identified the beds as the base of the Green River Group, or possibly the top of the Wahsatch Group.

meter in mean diameter; they thus give the cases a granulated appearance. Nearly all the cases are filled with calcareous material, but some are empty for a short distance from their mouth, and in one case the inner lining of this part of the case has a coating of minuter calcareous particles, evidently deposited therein after the case was vacated. As the present thickness of the walls indicates (as also the size of the attached pebbles), the silken interior lining of the case must have been very stout. This follows also from the appearance of one or two which have been crushed; for they have yielded along longitudinal lines, indicating a parchment-like rigidity in the entire shell. In one of the specimens the outer coating of heavier pebbles has in some way been removed by weathering, and has left a scabrous surface, apparently produced by minute, hard grains entangled in the fibrous meshes of the web; it still, however, retains its cylindrical form.

The size of the case, its form, and the material from which it is constructed, seem to indicate that it belonged to some genus of *Limnophilidæ* near *Anabolia*.

The following is the list of shells and fish and plants collected during the season:

List of fossils from the Green River Group.

MOLLUSCA.

Goniobasis tenera.	Big Sandy, near mouth of Little Sandy, Green River Basin, Wyoming Territory.
Unio Haydeni. *Cypris.*	Ham's Fork above Granger.

FISHES.

Mioplosus labracoides. *Mioplosus abbreviatus.* *Mioplosus* sp.? *Dapedoglossus testis.* *Diplomystus humilis.* *Diplomystus analis.* *Priscacara serrata.* *Priscacara serrata* (young). *Priscacara pealei.* *Clastes ferox.*	On Twin Creek, near southern edge of Ham's Fork Plateau, about latitude 41° 55′, longitude 110° 48′, Wyoming Territory.

FLORA.

Myrica n. sp. *Ostrya* n. sp.	Branch of Twin Creek, near Sublette's Road, Ham's Fork Plateau, Wyoming Territory.

BRIDGER GROUP.

The areas of the Bridger Group are few, and are all limited to the southeastern portion of the district. The largest area extends northward from Ham's Fork toward Slate Creek, breaking off in low bluffs in which the sombre clays and sands of the group are exposed. Between the mouth of the Big Sandy and the Green, on the east side of the former, there are variegated sands and marls much like those of the Wahsatch Group. They are, however, above the Green River shales, and have therefore been referred to the Bridger Group. They weather into Bad Lands. The beds of this group were not observed north of Slate Creek. On the east side of the Big Sandy north of the Green there appeared to be isolated patches of the beds, but they do not extend far to the northward.

The isolated character of the beds in our district does not allow us to predicate anything in regard to them, and I therefore leave them with this brief reference to their outcrops.

No fossils were collected.

PLIOCENE DEPOSITS.

At the end of the early Tertiary period there appears to have been an elevation which lifted the lake that had continued from Wahsatch time, so that it was completely drained. Accompanying this elevation there may have been a depression to the westward. Whatever the conditions may have been, it is certain that a large area in the western portion of our district was occupied by a lake that did not exist in Bridger time. This lake appears to have occupied depressed areas that were probably being eroded during the earlier Tertiary time. In Bear River Valley, below Bear Lake, as described in Chapter V, there is a series of conglomerates and sandstones, with calcareous layers, which are mainly horizontal in position, resting on Mesozoic and Carboniferous rocks. Near the middle cañon of the Bear the Pliocene beds consist of greenish and white shales and sands. They incline about 60°, and rest on Silurian limestones and quartzites, which dip almost in the same direction and at about the same angle as though they had been uplifted at the same time.

In various portions of Cache Valley, especially on the west and north sides, the beds are seen inclining toward the valley, where they are obscured by the Quaternary lacustrine deposits. Wherever they are seen in this region they are disturbed, showing that at the end of the Pliocene there was considerable disturbance.

I have retained the name of Salt Lake Group, given by Dr. Hayden for these beds. The southern end of Cache Valley is colored on the map published by the Fortieth Parallel Survey as occupied by the Humboldt Group. In our district the central portions are filled with later beds, to which, for the present, I give the name Cache Valley Group, separating from it the Pliocene Salt Lake Group, which corresponds to King's Humboldt Group. On Franklin Butte there are fragments of limestones that are probably Pliocene, but the rock could not be seen in position. Fossils were obtained from the rocks at several localities. The following are the genera recognized:

Limnæa sp.?
Planorbis sp.?
Sphærium sp.?
Valvata sp.?
Bythinella sp.?

TERTIARY OROGRAPHY.

In taking up this subject we find that the facts observed in our district are very meagre. During the deposition of the sediments of the Wahsatch Group, the evidence indicates a continued subsidence, which may also have continued during the deposition of the two succeeding groups.

Along the edge of the Wyoming Mountains the strata of the Wahsatch Group dip toward the Green River Basin beneath the Green River Group, and as far as seen conformably, the angle of inclination being from 4° to 10°. Along the Wind River Mountains they are also seen to rise, so that they have been affected by an elevation which appears to be of later age than that of the deposition of the Green River Group.

The Bridger Group is seen only in isolated places, where the underlying Green River Group is horizontal, so that it is impossible to say positively whether it was involved or not. There is no evidence in our district of disturbance at the end of the Wahsatch, at the end of the Green River, nor at the end of the Bridger. The elevation was, however, probably before the Pliocene, as the valley of Bear River below Bear Lake appears to have been eroded after the elevation of the Wahsatch covered Bear Lake Plateau. On the latter the Wahsatch beds show a gentle synclinal, and west of it dip steeply from the east side of the Bear River Range. At no point in the Green River Basin did I discover any Pliocene beds, so that the continuous uninterrupted section from the beginning to the end of the Tertiary cannot be made from the data obtained by us.

At the end of the Pliocene-Tertiary there was a great disturbance, which outlined the areas to be occupied by the Quaternary lakes. It is hard to say whether the lakes continued from Pliocene into Quaternary time, with simply a restriction to smaller areas and changing of their outline, or not. If the beds in Bear River Valley below Georgetown are Pliocene, and those beneath the basalt near Soda Springs are Quaternary, it would seem to indicate a period of erosion separating them.

In Cache Valley it is somewhat difficult to separate the Pliocene from the Quaternary, but wherever the former are seen they are always disturbed, giving evidence of the Post-Pliocene disturbance.

QUATERNARY.

In the general section given on p. 612, the Quatenary Groups of the district are given, not in the order of age, but according to their geographical position, with the exception of the drift, which is, of course, the latest. It is found impossible to treat the Quaternary formations of our district in a more systematic way than to take them up in the order there given.

Drift.—In nearly all the valleys and over large areas of comparative uniformity in level in the district there is spread a thin covering of drift, which is generally very local, being derived from the adjacent mountains. In Salt River Valley, however, the drift is conspicuous in the lower portion and is probably of glacial origin. The Salt River Range and the Wyoming Ranges appear to have had glaciers in their deep cañons, and at present have immense snow-banks, that during ordinary seasons do not entirely melt.

Salt Lake Conglomerate.—At various points in the lower valley of Salt River, especially on the eastern side, there are fragments of a limestone conglomerate, which is horizontal in position. I have included it with the Quaternary, although no facts were observed bearing on its age.

Malade Valley Group.—The soft sands and marls of Malade Valley containing forms of fresh-water shells are probably somewhat more modern in date than the similar beds in Cache Valley.

Cache Valley Group.—This name I have applied to the soft marls and sands which are best exposed in the northern side of the valley and on Bear River below the middle cañon. They are somewhat variegated and horizontal in position. The beds in the central portion of Gentile Valley containing *Limnæa Planorbis* and other fresh-water fossils are probably of the same age as are also possibly those of Malade Valley just mentioned.

The soft sandstones seen in the terraces back of Logan are, I think, older, and probably should be classed with the sandstones of Marsh

Creek Valley. They incline a few degrees, but this is probably due to deposition and not to a movement after their deposition.

Marsh Creek Group.—These beds as exposed on Marsh Creek above Red Rock Gap are very white, friable sandstones, which dip a degree or two from the mountains. Farther down the valley they are covered by the basalt flow. They are probably older than the deposits I have included under the Cache Valley Group.

Gentile Valley Group.—Near one of our sub-stations in Gentile Valley a coarse conglomerate outcrops, which was horizontal and seemed to be older than the soft deposits in the centre of the valley. In the Portneuf Cañon a similar conglomerate was noted, and also on the east side of Cache Valley. These beds I have provisionally designated the Gentile Valley Group.

I have not the space here to enter into any detailed description of the groups just mentioned. The reader is referred to Chapters IV and V for further details. That all the beds were deposited in fresh-water lakes there is no doubt. A view of the valley, in which they are found and their fossils indicate this. They represent a part of the great basin of which the Great Salt Lake Valley is a part. This fact was long ago recognized by Dr. Hayden. In the report for 1870 he says:

> Let us for a moment take a bird's-eye view of the great inland basin of which Salt Lake Valley forms only a part. We shall find that what is termed the Great Basin of the West comprises the vast area inclosed by the Wasatch Mountains on the east and the Sierra Nevada on the west, the crest or water divide of the Columbia on the north, and that of the Colorado on the south. We shall also observe that this great region has no visible outlet; that it is composed of a multitude of smaller basins or valleys, each of which has its little lakes, springs, and water-courses, their surplus water either evaporating or sinking beneath the surface. If we examine the elevations in this region, we observe a wonderful uniformity in the surface of the valleys, and find that none of them are much above the level of the waters of Great Salt Lake. (P. 172.)
>
> I infer that a vast fresh-water lake once occupied all this immense basin; that the smaller ranges of mountains were scattered over it as isolated islands, their summits projecting above the surface; that the waters have gradually and slowly passed away by evaporation, and the terraces left to reveal certain oscillations of level and the steps of progress toward the present order of things; and that the briny waters have concentrated in those lake basins, which have no outlet. (P. 170.)

The fact that Cache Valley was covered by one of these lakes was first indicated by Dr. Hayden in 1871*. To it should be added Marsh Valley, Gentile Valley, and Basalt and Upper Portneuf Valleys, and, possibly, the region of the Blackfoot, although the latter is now completely covered with basalt. The lake in this latter region probably connected with the Marsh Valley lake by way of the Portneuf Cañon, while Red Rock Gap, or Pass, was the point of structure connecting the lake of Cache Valley with that of Marsh Creek Valley. The point of outlet of the Marsh Valley lake was evidently somewhere beyond the junction of Marsh Creek and the Portneuf River. The axis of the Bannack Range probably formed the barrier which, when it was eroded low enough, allowed the Marsh Valley lake to be completely drained. The latter was probably a much shallower lake than that of Cache Valley. After it was drained the barrier was at Red Rock Gap. The elevation on both sides of the pass is about 5,000 feet or a little less, and the level of the lake, as indicated by the upper terraces, was at first about 5800 feet. When it reached the level of the Bonneville Beach it was 5,185.7 feet. The elevation of the Provo Beach was about 4,825.7 feet; so that when the gap was eroded below that elevation, the lake of the Provo level was drained from Cache Valley.

---

*Rept. U. S. Geol. Survey for 1871, 1872, p. 19.

In Cache Valley the terraces indicate several periods of comparative permanence below the level indicated by the Provo Beach. The fact that Red Rock Gap was a point of outlet for the lake that filled Cache Valley was first recognized by Professor Bradley in 1872, although Mr. G. K. Gilbert claimed its discovery in 1876.* It was my intention to enter more fully into this question in this report, but the elevations have not all been determined yet, and even if they were, the time is too limited to take it up at present. Suffice it to say that, 1st; the terraces point to the existence of a lake having a higher level than Lake Bonneville; 2d, the outlet of the lake indicated by the Bonneville Terrace was considerably north of Red Rock Gap, probably at the point where the Portneuf River cuts across the axes of the Bannack Range; 3d, Red Rock Gap was the outlet when the lake had the level indicated by the Provo Beach.†

To treat of the subject fully, the valleys of this region should be carefully studied, which would require an entire season to be devoted to them.

VOLCANIC ROCKS.

The volcanic rocks of our district are included under one head, viz, Basalt. The region covered with it is principally the Blackfoot Basin, in which are at present a number of extinct craters. There are indications that there were several flows. In this region the basalt is generally horizontal in position, and fills the valleys and depressed portions of the basin.

The craters in the Blackfoot basin were the sources of the flow that follows the Portneuf, and below the cañon separates the river from Marsh Creek. This belt of basalt appears to end before the Snake River plains are reached, although below the gap that separates Marsh Valley from the latter there is basalt. The basalt at Station 81 and the surrounding region is evidently older than that of the Blackfoot Basin. It rests on Pliocene rocks, which are tilted, appearing to have been poured out before the end of the Pliocene period; whereas, in the case of the basalt in Marsh Valley, the Quaternary deposits were somewhat eroded before the basalt was poured out. Under the heads Blackfoot Basin &c., in Chapter IV, the basaltic occurrences are described. We have therefore in our district both Pliocene and Quaternary basalt. The former appears to have been a flow at the close of the Tertiary, accompanying the orographic disturbances which occurred then. There were also two flows during the Quaternary, as indicated by the basalt in Portneuf Cañon and in Gentile Valley. In speaking of the basalt on the Snake River plain and lower portion of the Portneuf River, Professor Bradley says:‡

Here, again, we encounter basalt, but it seems to belong to a lower layer than that we left at Black Rock. All over the great plain, indeed, we find two or more layers of basalt, separated by greater or less thicknesses of sand and gravel, partly loose, partly consolidated by ferruginous, siliceous, or calcareous cement. If two layers should be found superimposed at any point in the upper part of the cañon, I should believe that they had resulted from two distinct eruptions from the volcanic source before mentioned [*in the craters near Soda Springs*]. As it is, it is not impossible that these layers in the outer plain have been ejected from some central source, have overflowed the plain, and so have run up into the mouths of the valleys opening upon it. It seems hardly possible that, after flowing seventy or eighty miles, the lava should still have retained sufficient fluidity to spread out in a solid layer over the plain. Whatever the source, the material had evidently become quite viscid; for at some

* See Amer. Jour. Sci. and Arts, Vol. XV, June, 1878, pp. 439–444.

† See Amer. Jour., &c., as above, and Chapter V of this report.

‡ Report U. S. Geol Survey of the Terr. for 1872, 1873, p. 204.

points, where it ran over small inequalities of the surface beneath, it now stands in low mounds, which would not have been the case if it had been very fluid. That these mounds were not all formed by an undermining and sinking of the surrounding mass, to which some of them have very properly been referred, is proved by the tapering shape of the closely-fitting blocks which form the arch.

Although I did find two layers of basalt in the upper part of the cañon separated, I am still inclined to think that the source of the basalt in the lower valley of the Portneuf was somewhere in the Snake River plain. Dr. Hayden was also of the opinion that the Snake River plain was a centre.

The source of the basalt that separates the Portneuf River and Marsh Creek is undoubtedly the craters in the Blackfoot Basin and Basalt Valley, as the connection is easily traced through the Portneuf Cañon. The craters that are still standing in the Blackfoot and Bear River region are very perfect. These basaltic flows extend into Mr. St. John's district, and the reader is referred to his report for details in regard to its occurrence there.

APPENDIX.

A.—Minerals of the District.

B.—Catalogue of Rocks.

A.

MINERALS OF THE DISTRICT.

The mineral of most importance in an economic point of view in our district is coal, which occurs at three or four localities. Salt is the next in importance, beds of this mineral occurring in the Salt River Region, which is also full of salt springs. As far as known, there are no mining localities in the district, which, as the report shows, is an area of sedimentary rocks, in which it is not probable that gold and silver deposits will be extensively found. The Bear River Range and the Malade Range, it is true, are said to have yielded silver-bearing ores, but it is probable that the areas are limited and will never become successful mining districts. It must be said, however, that comparatively little prospecting for ores has yet been carried on.

LIST OF MINERALS OF THE GREEN RIVER DISTRICT.

The list of minerals presented is meagre for the reason that time was too short to explore the natural cuts for specimens, and there were no mining districts within the areas explored by us.

Calcareous tufa.—Calcareous tufa was found at all the spring localities, of which the following is a list:

Soda Springs.—The specimens at this locality are particularly fine, especially those from the Formation Spring.

Twin Springs, at base of Soda Springs Hills

Cañon of Bear River, in Basalt Valley.

Gentile Valley, on Bear River.

Portneuf Cañon.

Calcite.—In the limestones of the Wyoming, and Salt River Ranges. In Preuss Range and Bear River Range.

Coal.—*Bituminous coal* (*lignitic*), at Twin Creek Mines; Smith's Fork; Bell's Pass, between Ham's Fork and Twin Creek.

Lignite, on Bear River, above Soda Springs; in Gentile Valley; on Smith's Fork of Bear River, near the forks of the river.

Feldspar.—*Orthoclase* in the granites of the Wind River foothills.

Obsidian in the basalts of the Blackfoot Basin.

Halite (common salt), in springs in Salt River Valley and on Smoking Creek. At the latter place there is only one spring that is being used at the salt-works. Two hundred thousand pounds of salt is the monthly yield.

HYALITE.—Coating basalts, on Station 81, south of Ross Fork of Snake River.

LIMONITE (pseudomorph after pyrite).—Ridge of Station No. 77 in the Bannock Range.

MICA (*muscovite*).—In the granites of the Wind River foot-hills.

OBSIDIAN.—(See *Feldspar.*)

ORTHOCLASE.—(See *Feldspar.*)

SALT.—(See *Halite.*)

B.

CATALOGUE OF ROCKS COLLECTED IN 1877 IN THE GREEN RIVER DISTRICT.

No.	Name, &c.	Locality.
1	Gray sandstone (Green River Tertiary)	Mouth of Little Sandy River.
2	Greenish-gray sandstone (Green River Tertiary)	Do.
3	Granite	Fremont's Butte.
4	White limestone (Green River Tertiary)	Near mouth of Horse Creek.
5–6	Oolitic limestone (Jurassic)	Meridian Ridge, south of Fontenelle Cañon.
7	Calcareous sandstone (Tertiary)	Ham's Fork of Green River.
8	Conglomerate	Ham's Fork, east of Oyster Ridge.
9	White limestone (Green River Tertiary)	Ham's Fork Plateau, near Sublette's road.
10	Conglomerate (Cretaceous ?)	Smith's Fork, near the forks.
11	Conglomerate (Wahsatch Tertiary)	Meridional Valley, on Horse Creek.
12	Red limestone (Triassic)	Below Wyoming Peak.
13	Red siliceous sandstone	Do.
14	Quartzite	Do.
15–17	Basalt	Valley of John Gray's Lake.
18–19	Scoriaceous basalt	Blackfoot River, in Hollow Hand.
20–22	Basaltic obsidian	Blackfoot Basin, west of river.
23	Basalt	Do.
24–25	Scoriaceous basalt	Crater in Blackfoot Basin.
26–27	Green chloritic schist	Bannock Range, near Station 77.
28	Basalt	Station 86, on crater in Basalt Valley.
29–30	Sulphur and calcareous tufa	Sulphur Lake, east of Soda Springs.
31–32	Coal	Twin Creek mines.
33	......do	Divide between Ham's Fork and Twin Creek.
34	Fire-clay	Twin Creek mines.
35	Coke	Do.
36	Basalt	Station 108 (Mount Kimball), Bear Lake Plateau.
37	Light-gray fossiliferous limestone (Jurassic)	West of Station 108 (Mount Kimball).
38	Red quartzitic sandstone	Station 117, in southern extension of Portneuf Range.
39	Bluish limestone (Silurian)	Cañon in Bear River Range, back of Smithfield.
40	Brown limestone (Pliocene)	Bear River, near Gates, in Cache Valley.
41	Chloritic schist (Cambrian)	Five-Mile Cañon, west side Cache Valley.
42	Blue limestone	Station 131, north end Cache Valley.
43	Oolitic limestone (Silurian)	Below Station 133, head of Marsh Creek.
44	Quartzitic shale (Silurian)	Do.
45	Slate (Silurian)	Do.

PART II.

TOPOGRAPHY.

REPORT OF A. D. WILSON, CHIEF TOPOGRAPHER.

LETTER OF TRANSMITTAL.

OFFICE OF THE UNITED STATES GEOLOGICAL AND
GEOGRAPHICAL SURVEY OF THE TERRITORIES,
Washington, D. C., March 24, 1879.

SIR: I have the honor to transmit herewith my report on the primary triangulation carried on during the seasons of 1877 and 1878.

Having completed the computations of the work of 1878 in time for this report, I determined to combine the reports for the two seasons in one.

I give only a running account of the field work, time not permitting me to give any detailed description of the country, but I hope circumstances will allow me to do so in the next report.

During the field season of 1877 I was accompanied by Ernest Ingersoll and William Shippen as general assistants; Harry Yount and John Stewart, packers. During the season of 1878, by A. C. Ladd, assistant; Harry Yount and Clarence Kelsey, packers, and Joe Foster as cook.

Hoping that the accompanying report may meet with your approval, I am, very respectfully, your obedient servant,

A. D. WILSON.
Chief Topographer.

Dr. F. V. HAYDEN,
United States Geologist in Charge.

REPORT ON THE PRIMARY TRIANGULATION OF 1877 AND 1878.

By A. D. Wilson.

In the spring of 1877, having completed the work in Colorado the previous season, it was determined that the survey should be carried north into Wyoming. The belt of country lying along and including the Union Pacific Railroad had been surveyed and mapped by the "Geological Exploration of the Fortieth Parallel" under Clarence King. Therefore the work was commenced at the northern line of this belt at Fort Steele, and thence carried north and west, including rectangles Nos. 45, 56, and 57, included between longitudes 107° and 112°, and from latitudes 41° 45′ to 44° 15′.

Three topographical parties were sent out; to each was assigned a rectangle. Mr. Chittenden was given rectangle No. 57, which he nearly completed; Mr. Gannett had No. 56, who completed his section; while Mr. Bechler had No. 45. This rectangle included so much high and difficult country, and Mr. Bechler being compelled to leave the field earlier than he would have done on account of the Indian troubles, he did not finish more than half of this section.

The parties were all fitted out at Cheyenne, Wyo., and then shipped along the railroad to the most convenient points to their work; my party stopping at Rawlins, Mr. Chittenden's at Salt Well, Mr. Gannett's at Green River, while Mr. Bechler's went through to Ogden. The primary triangulation was, as usual, placed in my charge. Arriving at Rawlins Springs May 31, I established my camp about two miles out of town, at Cherokee Springs. After reconnoitering the country in the vicinity of Rawlins, I selected a place west of the town, between Separation and Cherokee Peaks, as the most favorable spot on which to measure a base-line from which to start this work. Although the ground was not all that I could have desired, it was the best that could be found in the vicinity, nor was there as much room as I wanted; but owing to the favorable conditions it offered for connecting with the mountain peaks, I selected it in preference to any other that I could find.

MEASUREMENT OF THE RAWLINS BASE-LINE.

The central portion of the line as selected lay along a "tangent" of the railroad, and the remainder extended over a sage-brush flat where there was considerable brush; and the ground being full of small hummocks, I determined to measure the portion lying along the centre of the track, which was about one mile in length, and to expand by means of signals placed so as to form nearly equilateral triangles, and in this manner extend the base either way as far as the conditions of the surface would allow.

The line was measured along the centre of the track with a fifty-foot Stackpole compensated steel tape; this tape was compared with a Ches-

terman steel tape which had been compared with the Coast Survey standard at different temperatures, and was not used except as a standard. The comparisons were made before and after each measurement of the line; in this way the stretch of the tape was obtained. The line was carefully measured three times, using low stools to raise the tape from the ground, and fine steel pins as markers.

The variation between the three measurements was one and one-half inches; a mean of these results was taken as the true length, after correcting for slope, temperature, and stretch of tape, and reduction to sea-level. The mean error of closure of the triangles used in expanding the base was five and three-tenths seconds. The triangles being so nearly equilateral and the distances so short, error was hardly perceptible. In this manner the line was expanded to a length of three miles. Taking this as the base, also using the point of expansion, the work was farther expanded to Cherokee, Rawlins, Separation Peaks, and Mount Steele, signals having been previously placed on these points, thus expanding the base to a length of nearly twenty five miles, with an average error of closure in the triangles of 8″.8. This I considered a very fair result under the circumstances, as the instrument used was only an 8-inch circle, graduated to ten seconds; besides, we were troubled by heavy cold winds nearly all of the time while engaged on this work.

Leaving Rawlins on June 11, we marched northward to the Seminole Mountains, where, on the 13th, I made a station on the highest point of the range, to which we gave the name of Seminole Peak. Thence flanking the mountains on the south, we marched westward to Whisky Peak, a point just west of Whisky Gap, where I made another station. From this point we continued, crossing a rolling, grassy country swarming with elk, deer, antelope, and now and then a few stray buffalo would be seen slowly strolling over some distant hill.

Our next point was Yellow Butte, where a day was spent in taking observations from the peak for the triangulation, and azimuth observations were taken at camp during the evening.

Resuming our march the following day, we proceeded to Camp Stambaugh, where a fresh supply of provisions had been shipped with other necessary outfit to enable us to continue our work.

Leaving Stambaugh on June 21, we marched along the southern foot of the Wind River Mountains until we reached the western fork of the Sweetwater. Following up this stream as far as we could conveniently with the train, we camped for the night. Leaving the camp here I took a small outfit, with provisions, blankets, and instruments, continued up the stream, and with some difficulty reached a point near the pass at its head, where we found further progress impossible with animals on account of deep snow, which filled the valley from this point upward. Leaving our animals here, I proceeded on foot, accompanied by Ernest Ingersoll and Harry Yount, to ascend Wind River Peak, the highest point in this portion of the range. After a very fatiguing climb through the snow for about five hours, we reached the summit only to find the wind so strong and so intensely cold that it was impossible to set up the instrument or do any work. Thus all of this hard climb was only for nothing, returning to our camp by nightfall well-nigh exhausted. During the night the storm broke and continued for two days, compelling us to lay by until it was over.

On the morning of June 27, the weather being clear, I started by 4 a. m., accompanied this time by William Shippen and Harry Yount. The snow being hard enough to bear us up, we made good time, arriving on the summit before ten o'clock; and the weather having settled some-

what, we soon got to work, and I succeeded in getting a very good set of angles to all the surrounding points, except to the north and northeast, where the clouds hung so low that the points were hidden; but as these points did not come within the area to be surveyed that season, I concluded not to climb this point again at that time. Looking down from this point upon the great field of snow, I suspected (what proved to be true the following season) that there were living glaciers in some of the amphitheatres at the head of the cañons, which were at that time so concealed by fresh snow that they could not be readily distinguished at a distance. We found the descent in some places even more fatiguing than the ascent, as the snow had softened under the noonday sun so much that we often fell in up to our arms, and in scrambling out we gradually became wet, until we were well soaked by the time we reached our bivouac; but once there we soon saddled our mules and returned to our main camp by nightfall.

The following morning, June 28, accompanied by Harry Yount, I made the ascent of West Atlantic Peak and took a set of observations, which completed my work on the southeastern end of the range.

The morning of the 29th found us traveling on westward skirting the foot of the mountains through a snow-storm, accompanied by a heavy, cold west wind, making it very disagreeable traveling, especially as it came fair in our faces; nevertheless we made about 20 miles, camping for the night on the Big Sandy.

The following day we continued our march, keeping near the foot of the great granite plateau which here flanks the range, here and there crossing some projecting moraine which extended out into the valley, but the next day brought us fairly into the great morainal region along the head branches of the New Fork of Green River. Here the glaciers appear to have reached their maximum size, and are the finest examples of the kind that I have ever met with anywhere in the West. Crossing these ridges of granite *débris*, we found here and there some of those beautiful glacial lakes which lay imbedded between those great moraines, rising in some places to a thousand feet above the lakes, and extending six to seven miles beyond the foot of the plateau into the valley below. The glaciers here must have been from twenty to twenty-four miles long, extending from the summit of the range across the plateau and far in the valley below, scooping out the great basins which are now occupied by the lakes as it poured over the edge of the plateau.

Leaving my camp by one of the lakes at the foot of the plateau, I took a pack-mule with supplies to last two or three days and started for the point I then took to be Frémont's Peak. Following up one of the morainal ridges we reached the plateau, which we found covered by snow to a considerable depth. After a hard struggle through several miles of snow-covered granite boulders, we reached a point near the foot of the peak where we found a small spot from which the snow had melted off. Taking advantage of this, as it offered some food for our animals, we camped for the night.

The following morning, July 3, we were off on foot by the break of day for the peak, reaching the summit by nine o'clock. I was soon at work and by noon had finished the observations that were wanted from this point. Having a more comprehensive view of the country from this point, I concluded that I had been mistaken as to this being Frémont's Peak, and came to the conclusion that it was a point some eight or nine miles to the north. But the intervening country was so deeply covered with snow that it would be almost impossible to reach it at that time of year.

Having finished the work, we soon slid down the mountain to camp, and packing up in haste we started for our main camp; the trail being broken, we made good time, reaching camp in time for a splendid supper of lake trout and roast venison.

My next point being the highest peak in the Grosventre Range, we continued our course along the foot of the range, keeping close under the mountains to avoid the large streams, as the snow was melting pretty fast and swelling the streams until even the smaller branches were becoming difficult to cross.

The third day's march brought us to the foot of Grosventre Peak quite early in the day, and, being able to camp very near the point, I ascended the peak and had a fine afternoon for work. The weather was both calm and clear. This we considered a great treat, as we had not been so fortunate on any of our higher points before. The weather up to this time had been very cold and windy nearly all of the time.

It was my intention to have continued toward the northwest, and to make a station on the Grand Téton; but I found that it would be almost if not quite impossible to cross even the larger branches of the Snake River, to say nothing of the main stream, which is generally hard to ford even when the water is low. I determined, therefore, to turn toward the southwest and in that way avoid the large streams until later in the season.

Crossing the basin of Hoback's River, we made a station on a peak of the same name near the northern end of the Wyoming Range; thence keeping along the eastern part of the range toward the south. I ascended Wyoming Peak, a fine conical-shaped mountain near the south end of the range and the highest point. Continuing southward, we struck the old Lander road, which we followed toward Fort Hall. Making a station on Caribou Mountain on the way, we arrived at Hall on the 20th of July. Learning here that it would be impossible to cross the Snake River and reach the Téton Range without going far out of our way, I thought best to abandon my idea of reaching that portion of the country until another season, when it could be reached without the loss of so much time. After replenishing our supplies here, we turned our steps southward. Making a station on Mount Putnam, we continued, by way of Soda Springs, to a place called Georgetown, in Bear River Valley, lying between Mount Preuss and Soda Peak. Here I selected a smooth grassy valley in which to measure a second base, or base of verification. After selecting the place, I staked out the line and had all the sage brush, tall weeds, and grass removed, so there should be no obstructions in the way. The measurement was conducted in the same manner as the first base. The line was about two miles long, and was measured three times as before; the difference between these three measurements was one and two-tenths inches; the mean of the measurements was taken as correct after reducing for slope, temperature, and stretch of tape, and the final result reduced to sea-level. Expanding as before by means of signals placed on some adjoining hills, the distance between Mount Preuss and Soda Peak was determined, thus obtaining a line about fifteen and a half miles long. The mean error of closure in the triangles used in the expansion was ten seconds. The two points thus connected were points that had already been used or selected as stations during the progress of the former work. This work had occupied us some seven or eight days; after its completion we moved on southward, making stations on Paris and North Logan Peaks. Returning from the latter point to Bear Lake, we followed up the river to Evanston, where I connected the triangulation with a latitude station made

at this point by the boundary survey of Wyoming; also made a station on Medicine Butte, thus connecting with my former work under Clarence King in 1871 and '72.

From Evanston we marched eastward by way of Fort Bridger and Green River City to Pilot Butte, another one of my old points. Here I spent two days, owing to the smoky condition of the weather, in obtaining the necessary sights.

We next visited Black Butte, also one of my former stations; thence returning to Rawlins. I revisited Separation Peak to obtain sights to Wind River and Atlantic Peaks, not being able to see these points on my first trip, as they were covered by clouds. Remaining on the point all night, I succeeded after sunset and before sunrise in obtaining the required observations.

After taking another set of azimuth observations from camp under Rawlins Peak, I started my party for Cheyenne, there to be disbanded for the season. Taking my theodolite, I took the train for Ogden, where I connected the triangulation through Ogden and Willard Peaks with the observatory established there by the Geographical Survey West of the One Hundredth Meridian, under Lieut. G. M. Wheeler. I also connected the work through the triangulation of the Geological Exploration of the Fortieth Parallel with the astronomical station made at Salt Lake City by the Coast Survey.

REPORT ON THE PRIMARY TRIANGULATION OF 1878.

Headquarters of the survey was at Cheyenne, as it had been the previous season. The parties were fitted out as before, and shipped to their respective points of departure. Mr. Jackson's party was shipped with mine to Point of Rocks station, on Bitter Creek, where we arrived on the morning of July 26. The day was spent in putting our luggage and supplies in shape for transportation on the mules.

The following morning, after the usual amount of trouble to get under way, we started northward toward the Wind River Mountains, continuing our course without interruption until we reached the eastern branch of the Little Sandy on the forenoon of July 29; here we halted to observe the total eclipse of the sun, and we were very fortunate in having a splendidly clear day. The only observation we took was on the time of totality. I observed with the telescope of my transit, Mr. Holmes with the smaller glass of the gradienter, and Mr. Eccles with a smoked glass. I made the time of totality 2 minutes 27½ seconds; Mr. Holmes, 2 minutes 27 seconds; while Mr. Eccles made it 2 minutes and 26 seconds.

It is not my intention to attempt here any description of the scene, but will simply say that it was very interesting, and the effect quite curious on all who observed it.

The next day we reached the foot of the Wind River Mountains, where we left the greater portion of the party to await our return. We started on the morning of July 31, following up the west branch of the Sweetwater, as we did the previous season, but finding that the snow had all disappeared from the pass, we crossed the pass and followed up a branch of the Big Popo Agie, and camped by a small lake near the southeastern foot of the peak.

On the morning of August 1 we took an early start, and being able to ride to within a thousand feet of the summit, tying our animals to some large rocks and shouldering our instruments, we soon reached the top of Wind River Peak. Looking down toward the northeast, we saw plainly before us a very fine specimen of a living glacier; this I had suspected the previous season, but at that time could not determine the

fact without a more careful examination, owing to the whole surface being covered with a heavy coating of fresh snow. While we were taking our notes, Mr. Eccles descended to this ice field and examined it very carefully, pronouncing it a well-defined glacier. The day being a very fair one, I succeeded in obtaining a good set of observations, but was not able to get sights as I had hoped to do to the peaks in the Bighorn Mountains; these points being between 150 and 160 miles distant, the smoke or haze obscured them, yet under favorable circumstances they are visible. On my first visit in 1877, when the weather was too cold and windy to take any observations, I could clearly distinguish every point in the range; but it is seldom that the weather is so perfect that such long sights can be obtained. I have often found that such long sights could be observed just before sunrise or just after sunset, as the case might be, when the points were projected against a bright luminated sky, while the shaded side of the mountain presented a very dark appearance, thus bringing them out in bold relief; but as this is a very inconvenient time to be on the high peaks, one can seldom take advantage of this fact except from the more accessible points. Completing our notes and sketches, we soon descended to our camp by the lake. During the day Mr. Jackson had taken some excellent photographs of the mountains and lakes surrounding the camp.

The next point that I wished to visit being Frémont's Peak, after returning to our main camp, we followed very nearly the same course as the previous season, along the foot of the range until we reached Frémont's Lake. Here we left the greater portion of the party, and taking a small outfit, only sufficient to last us three or four days, we followed along the eastern shore of the lake for some distance, when we turned up to the right. Taking the ridge, we found very easy traveling until approaching the mountains, where we began to find our way obstructed to some extent by granite boulders, and between them the soil was wet and marshy. Working our way along for some distance we came to a lake surrounded by steep granite slopes which we could not pass with our animals, compelling us to halt. Camping here for the night, we made all necessary preparations to attempt the ascent from this point on foot.

About three o'clock in the morning of August 7 the cook called breakfast and the boys were soon out and by four were off for the peak. After a very tiresome walk over the rolling granite ridges, and scrambling around the glacial lakes, here and there impeded in the great granite basins formed by the ancient glaciers, we reached the foot of the main peak. From this point to the summit there was nothing but steady climbing over granite *débris* for about 3,000 feet. Reaching the summit about 10 a. m., we found no signs of any one having visited this point before; but I am of the opinion that this is the point that Frémont ascended in 1842, while executing his exploration across the continent at that time, judging only from his description of the country. From the top we looked down on quite a fine glacier which lay at the north foot of the peak and stretched off to the northeast for some distance, while other smaller specimens could be seen hanging in the heads of the surrounding cañons.

Completing our work, we retraced our steps, reaching camp just before dark considerably fatigued, but well pleased with the results of our day's work. The next day we returned to our main camp, where we remained over a day to enable Mr. Jackson to take some photographs of the lakes in the vicinity.

From Frémont's Lake we marched northwest across the Green River Basin to the head of Hoback's River, which we followed down to Snake River; thence up the latter to the mouth of the Little Grosventre. Leav-

ing the other parties to continue up the river, I crossed over to the west side, thence by way of Téton Pass to Pierre's Hole, continuing northward until we reached Téton Creek; turning short to the right, followed up the stream some distance, camping near the head of the open valley, which here extended two or three miles up the stream from the main valley below. Here I left the train with two of the men. Taking one pack-mule loaded with the instruments and sufficient supplies to last three or four days, started for the peak, accompanied by A. C. Ladd and Harry Yount. We succeeded in reaching the plateau west of the peak, which is considerably above timber-line, without any difficulty. We traveled along until we were cut off by a deep and very abrupt cañon. We might have taken our animals down to the bottom of this cañon if the pass had not been blocked by a heavy bank of snow. Finding ourselves blocked, we turned toward the south into a basin where we found grass and timber enough to camp by. Here we were delayed two or three days by a heavy rain and snow storm which we found very disagreeable, camped as we were on the side of the mountain exposed to the west winds. While we were thus delayed by the storm, I took advantage of a short lull by climbing to the edge of the plateau-like ridge to the southeast of camp. I obtained a very fair view of the peak and its approaches. While thus employed I looked down upon a bank of snow just below me, and there saw four grizzlies playing "hide and go seek" among the crevasses. Getting myself in a good position among the rocks, so they could not see me, I fired three or four shots at them, killing two of them; but finding that I had but one cartridge left, and two bears, I thought discretion the better part of valor, and slipping down on the opposite side of the rocks, "lit out" for camp.

On the morning of August 20, finding the weather very clear and beautiful, with a bright moon shining, we were up and off before daylight. Climbing to the top of the pass, we could then see what was before us. First, we had to cross a cañon that was some 1,500 feet deep, and then cross a spur which juts out south of the main peak, before we could really begin the ascent of the peak proper. We soon scrambled our way down to the bottom of the cañon, but not so soon did we reach the ridge beyond; the slope being very steep and the *débris* which composed it very fine and loose, it would slide from under our feet, making it very tiresome, especially near the top of the ridge. Reaching the top in a deep notch, we soon climbed down over a bank of *névé* snow and out on a small glacier, which filled the amphitheatre, or basin, at this point. Crossing this quickly, we found ourselves face to face with the peak itself, and it did look as if it would be almost impossible to climb to any height on this peak. We halted a minute to examine the ground ahead. I concluded to follow up a long slide which came from the southwest side of the peak; this would enable us to reach the saddle on the main ridge. So we proceeded to scramble our way over this great loose mass of angular boulders of granite, first giving strict orders that the others were not to follow in line, as it would be impossible to prevent the boulders rolling from under our feet with all the care that was possible. After about one hour's hard climbing over this *débris* slope, we found ourselves on the saddle, where we halted again for a moment to take a look at the peak from that side. I found that from this point there was a sort of hall-way, leading nearly to the summit, with nearly vertical walls of granite on either side. These walls extended below the saddle on either side, thus compelling us to follow this path, although very steep and in many places worn smooth by the snow slides which pass down this channel every spring. Taking the lead, as before, I climbed along, carrying my transit with but little difficulty for some distance,

until I came to a place where the rocks were well polished and standing almost vertical; but, not daunted, I started up, finding here and there a finger-hold or a crack in which I could stick my toe; finally reached a place where there was good footing; here I waited for my two companions, but had not waited long when a cry of "Help" came from one of them. I immediately crawled out on a jutting stone, and, looking down, I saw, about 40 feet below, one of them clinging to the face of the bluff, reminding me of a starfish hanging to a breakwater. He had gotten himself in such a position that he could neither get up nor down. Casting him the end of the rope, which he caught, and, thus aided, he was soon up with me. Another lift or two, the climbing became better, the rocks becoming more broken, thus offering better hold for hand and foot. We were soon up to the notch, which is formed by the two walls as they cross the peak; but, much to our chagrin, we could find no means of getting up the one to our right, which we must do to reach the high point. At the lowest point this wall is about 40 feet high, and is a smooth vertical wall of granite, without a break anywhere that a man could possibly crawl up. Thus we found ourselves completely blocked within a few feet of the top, after a long and tiresome climb of nearly 5,000 feet on foot. Turning to the left, we climbed to the top of the western point, where we found a circular inclosure of rocks, such as are often found on many of our Western mountains, evidently built by Indians; also a pile of rocks with a stick stuck in its center, left by some white man; the former very ancient, while the latter had been left there only a few years. These two marks told the whole story; evidently the builders, like ourselves, had been unable to reach the highest point. From this point I could see the opposite wall from top to bottom, but at no point could I discover a break, much to my disappointment. Now for the first time, after climbing hundreds of peaks during my twelve years of experience, I was compelled to give up reaching the summit, at least from that side. It is just possible that the top might be reached from the southeast; but it would have taken us several days to go back and recross the range and approach the peak from that side. I thought best to make the best of my present opportunity. Therefore I set up my instrument and took what observations I could. These being reduced to centre, they enabled me to connect the work northward. I determined to continue northward, trusting that I might have an opportunity of trying the ascent of the peak later in the season when on my way back. Completing my observations from this point as quickly as possible, we commenced to retrace our steps, and did not find it much easier than the ascent; especially when we came to climb out of the cañon we found that we were well-nigh exhausted; but at last we reached our side camp, and, as we had eaten our last provision in the morning, we determined to try and reach our main camp. We packed up in a few minutes and started down the mountain, reaching camp some time after dark, and greatly to our delight we found the cook had prepared a good supper for us, having anticipated our return.

The following August 21 found us on our way toward Sawtelle's Peak. Marching toward the northwest over a rolling grassy valley, we crossed Henry's Fork just below the Big Bend, thence following up the valley, which we found heavily timbered for some distance, but finally we struck the stream again where the valley becomes more open. There the stream flows along in its gentle winding course, filled with great white swan, geese, ducks, and other water-fowl, while the valley was full of sand-hill cranes. Each making its peculiar noise created a great bedlam of life in this wild and lonely place.

On the evening of August 24 we reached the valley of Henry's Lake,

and camped at its lower end. The following morning, leaving camp where it was, we rode to the top of Sawtelle's Peak, and having one of those magnificently clear days, I obtained a splendid set of angles to all the points that are visible from this peak. While I was taking my notes, Harry shot a fine mountain sheep, which we loaded on the mule that carried the large transit, and returned to camp just before night. After dinner we were lying about the fire, smoking and talking, when suddenly, all unconscious of any approaching danger, some shots were fired just behind us, and as quick as a flash we all drooped to our hands and feet and crawled for our rifles, some one calling out "Indians." Just as I picked up my rifle I heard our stock start off on the run. I knew at once that we were left on foot beyond all redemption, as the Indians were on horseback and already had the start of us. We remained in camp some time, but finding that the Indians still lurked about, I came to the conclusion that they intended giving us another trial at daylight, and as there was nothing to be gained by keeping the camp, as we could take nothing away except what we could carry on our backs, at the same time the camp was in an exposed position, therefore I determined to crawl out to some woods, where my little party of five, with our four guns, might stand a better chance if they should find us. Gathering up what was necessary in the way of provisions and blankets to last us three or four days, and taking our guns and ammunition, we started, first caching the instruments. Crossing the river, we felt our way along to the woods, where we lay down for a nap. As I had suspected, just at daylight the Indians fired into the camp, evidently to see if we were there. As soon as it was fairly light, we started along, striking for the Lower Geyser Basin, where I hoped to intercept one of our parties. If we failed in this, we would have to go to the Mammoth Hot Springs, a distance of 150 miles. After walking some distance, we succeeded in reaching a point from which we could see our camp. I could see with my field-glass that the camp had been demolished; also saw two Indians on horseback apparently looking for our trail. After a long, tiresome walk over the plateau, we were compelled to camp dry, not being able to find any water. Next morning we started just before daylight, hoping to reach water before it got hot. We had just started when a meteor shot across the cañon out of which we were climbing, lighting up the whole heavens as bright as noonday sun, and shortly after there came a peculiar sound very nearly like thunder, yet very different. Not suspecting anything of the kind, I did not take the time between the appearance of the meteor and the sound, which would have given me the distance of the meteor. After three days' hard walking we reached the Upper Geyser Basin, where we found Dr. Hayden and some of the other parties.

Procuring three mules, two riding and one pack, from Mr. Jackson's, I started back the next morning, accompanied by faithful friend Harry Yount, to rescue the instruments if possible. Reaching the camp about noon the second day, we found everything scattered and torn up; all the provisions, blankets, and many other things had been carried off. But fortunately they had not found the instruments that we had hidden. Loading our one pack-mule with instruments and a few other things that we picked up about camp we started back, and on the evening of the third day reached the Geyser Basin again.

Joining Mr. Jackson's party, we proceeded to Heart Lake, where he photographed the geysers, while I made a station on Mount Sheridan. From this peak we had a splendid view of the whole Park, with its many crystal lakes embedded in the black-green forests which cover

nearly the whole surface of the Park. All could see the great rows of snow-clad mountains which surround the Park nearly on all sides.

Leaving Heart Lake on the morning of September 7, we pushed our way through to Bottler's ranch, on the Yellowstone, in four days. Mr. Eccles had left his small outfit of mules here for me. Obtaining, besides these, two or three mules from Messrs. Jackson and Gannett, I was able once more to resume my work; but much valuable time had been lost, as the snow would soon close down on us.

Returning to the Mammoth Hot Springs, I found General Miles and party. He had encountered my friends of August 25, killed eleven and captured some thirty-five, besides a large herd of horses and mules, losing two men in the fight. After occupying Electric Peak, I moved southward, making a station on Mount Washburn with much difficulty, owing to a heavy snow-storm which caught us near this point. The whole Park was now covered with from six inches to a foot of snow (September 24), while on the mountains it was much deeper. After the storm, we continued southward up the Yellowstone. Passing the lake on the eastern side, we continued up the Upper Yellowstone nearly to its head, hoping to make a station on Yount's Peak, situated at the head of the river. But here we were caught in another heavy snow-storm, which blocked us completely from any further work in that portion of the country. Finding myself thus blocked, I determined to get out before it would be too late to cross the range.

Marching by way of Two Ocean Pass thence southward by way of To-gwo-tee Pass, we came out in the valley of Wind River after five days of hard struggle through the snow, timber, and rocks; following this valley to Camp Brown, thence by forced marches to Rawlins on the Union Pacific, but not without another storm, which caught us the last day, while marching across the open country between Whisky Gap and Rawlins. This was one of the worst snow-storms I ever encountered; the wind was blowing so hard that one could not see hardly twenty paces ahead, and the cold was intense. We finally reached the station just before dark, nearly frozen and well-nigh exhausted.

I was in hopes of visiting Fort Steele and making another connection with the astronomical station made there by Lieutenant Wheeler's survey; but the storm had been so severe and the weather continued cold and windy, I determined to close up for the season. Loading everything on the cars, we arrived in Cheyenne on the 17th of October, and soon after were on our way to Washington.

The accompanying map shows the positions of all the stations that were occupied, also some of the more prominent points that were located by foresights, while the accompanying tables give the latitudes, longitudes, and elevations so far as known, also azimuths and distances between the different peaks. Monuments were built on all of the occupied points.

The area covered by the triangulation of the two seasons was about 39,000 square miles; within this area there were forty-five points well located, besides some secondary points that are not given here, but have been used in the construction of the maps.

Azimuths were taken at various points and carried through from one point to the other, thus checking each other. The method of adjustment was essentially the same as used in the Colorado work, given in the report of 1876.

When the two bases were connected through the triangulation, there was found to be a difference of nearly one foot per mile. This difference is undoubtedly due to the connection across the Green River basin, where, owing to the lack of points, I found it very difficult to obtain

well conditioned triangles, and the distance being so great, the haze of this great plain played an important part.

The latitudes and longitudes are based on the United States Coast Survey station at Salt Lake City, checked by that of Lieutenant Wheeler at Ogden, the two checking each other very closely. I was in hopes of carrying this work eastward and connecting with the United States Coast Survey station at Sherman before publishing this work, but, owing to the unavoidable delays, I was unable to accomplish this during the past season.

A list of primary triangulation stations, with their latitudes, longitudes, and elevations above sea-level.

	Latitudes.	Longitudes.	Elevations.
	° ′ ″	° ′ ″	*Feet.*
East end of Rawlins base-line	41 25 23.4	107 18 15.0	6,800
West end of Rawlins base-line	41 46 16.5	107 21 30.6	6,800
Rawlins Peak	41 48 14.9	107 16 14.9	....
Cherokee Peak	41 48 54.6	107 19 42.8	....
Separation Peak	41 38 14.4	107 23 53.5	8,500
Mount Steele	41 50 14.8	106 59 59.6	7,770
Rattlesnake Peak	42 10 01.7	107 03 35.9	....
Seminole Peak	42 15 23.5	107 14 30.0	9,930
Whisky Peak	42 18 36.7	107 34 34.5	9,273
Yellow Butte	42 16 05.3	108 43 18.0	8,456
Black Butte	41 33 29.4	108 48 12.7	8,170
Essex Mountain	41 58 22.2	108 58 20.6	8,750
Wind River Peak	42 42 29.7	109 09 54.5	13,400
Pilot Butte	41 38 34.0	109 21 19.6	7,900
Atlantic Peak	42 36 59.3	109 00 16.5	12,700
West Atlantic Peak	42 37 17.2	109 01 07.3	12,634
Mount Bonneville	42 51 35.1	109 20 48.2	....
New Fork Peak	42 59 58.3	109 35 36.9	....
Frémont's Peak	43 07 28.5	109 37 17.3	13,790
Grosventre Peak	43 16 54.4	110 14 00.5	11,570
Hoback Peak	43 05 04.2	110 34 27.3	10,990
Wyoming Peak	42 36 14.9	110 37 39.7	11,490
Medicine Butte	41 21 06.5	110 54 42.5	8,769
Ogden Peak	41 11 56.7	111 53 09.5	....
Willard Peak	41 21 44.9	111 57 53.1	....
North Logan Peak	41 54 39.1	111 40 46.5	10,004
Lake View Peak	41 57 35.9	111 14 07.3	7,795
Paris Peak	42 12 08.8	111 33 11.8	9,522
Soda Peak	42 27 53.7	111 33 11.4	9,683
Mount Preuss	42 29 42.6	111 15 11.0	9,979
East end of Bear Valley base-line	42 27 18.9	111 19 48.0	6,100
West end of Bear Valley base-line	42 27 22.7	111 22 04.0	6,000
South Hill	42 23 41.1	111 23 34.4	6,600
North Hill	42 31 15.6	111 24 54.5	6,800
East Hill	42 28 49.7	111 19 19.6	6,500
Caribou Mountain	43 05 36.2	111 18 56.7	9,854
Mount Putnam	42 57 10.6	112 10 09.4	8,923
Mount Baird	43 21 46.7	111 05 54.8	9,990
Grand Téton	43 44 29.6	110 48 22.8	13,691
Yount's Peak	43 58 56.2	109 52 11.7	11,700
Washakie Needle	43 44 51.7	109 12 19.7	12,000
Mount Sheridan	44 16 00.2	110 31 58.8	10,377
Sawtelle's Peak	44 33 51.2	111 26 55.0	10,013
Mount Washburne	44 47 53.5	110 26 14.9	10,315
Electric Peak	45 00 22.2	110 50 28.3	11,155
Mount Hilgard	44 55 03.8	111 27 57.6	11,000
Emigrant Peak	45 15 50.2	110 42 37.7	11,034
Index Peak	44 58 36.6	109 53 04.0	11,500
Laramie Peak	42 16 00	105 26 50	....

Azimuths and distances from east end of Rawlins base-line to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Separation Peak	30 37 39	9.55470
West Base	109 55 34	2.986405
Cherokee Peak	162 43 34	4.23899
Rawlins Peak	207 40 23	3.71019

Azimuths and distances from west end of Rawlins base-line to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Separation Peak	12 31 59	9.46648
Cherokee Peak	207 02 25	3.41083
Rawlins Peak	243 22 19	5.06674
East Base	289 53 24	2.986405

Azimuths and distances from Cherokee Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Separation Peak	16 22 27	12.78933
West Base	27 03 33	3.41083
Yellow Butte	114 01 32	78.1857
Atlantic Peak	123 18 34	102.2309
Whisky Peak	159 37 46	36.4532
Seminole Peak	188 19 12	30.7754
Rattlesnake Peak	209 33 35	27.9495
Mount Steele	264 42 37	17.03304
Rawlins Peak	284 19 07	3.07766
East Base	342 42 35	4.23899

Azimuths and distances from Rawlins Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
East Base	27 41 52	3.71019
Separation Peak	29 49 27	13.26133
West Base	63 25 57	5.06674
Cherokee Peak	104 21 36	3.07766
Whisky Peak	155 52 48	38.2890
Seminole Peak	182 44 16	31.2515
Rattlesnake Peak	203 21 15	27.3085
Mount Steele	260 34 10	14.17113

Azimuths and distances from Separation Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Black Butte	86 10 37	73.0016
Essex Mountain	106 25 29	84.5155
Yellow Butte	122 59 39	80.8876
Atlantic Peak	129 50 57	93.4842
Wind River Peak	130 18 05	115.6760
Whisky Peak	168 53 18	47.3247
Seminole Peak	190 38 07	43.4797
West Base	192 30 22	9.46648
Cherokee Peak	196 19 40	12.78933
Rattlesnake Peak	205 23 00	40.5068
Rawlins Peak	209 44 20	13.26133
East Base	210 33 52	19.55470
Mount Steele	236 00 47	24.789665

Azimuths and distances from Mount Steele to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Separation Peak	56 16 42	24.789665
Rawlins Peak	80 44 59	14.17113
Cherokee Peak	84 55 46	17.03304
Whisky Peak	137 56 16	44.0687
Seminole Peak	156 48 30	31.4766
Rattlesnake Peak	172 16 45	22.9614

Azimuths and distances from Seminole Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Rawlins Peak	2 45 23	31.2515
Cherokee Peak	8 22 40	30.7754
Separation Peak	10 44 24	43.4797
Black Butte	59 37 24	93.8326
Yellow Butte	91 05 59	75.8750
Whisky Peak	102 17 51	17.5406
Atlantic Peak	106 00 32	93.4844
Wind River Peak	108 32 53	101.4509
Rattlesnake Peak	303 24 36	11.1752
Mount Steele	336 38 46	31.4766

Azimuths and distances from Whisky Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Black Butte	51 02 34	81.8053
Yellow Butte	87 33 14	58.7687
Atlantic Peak	106 38 27	75.9911
West Atlantic Peak	106 44 48	76.8151
Wind River Peak	109 37 26	84.0403
Washakie Needle	140 49 17	129.0398
Seminole Peak	282 04 23	17.5406
Rattlesnake Peak	290 16 51	28.2537
Mount Steele	317 33 07	44.0687
Rawlins Peak	335 40 31	38.2890
Cherokee Peak	339 27 55	36.4532
Separation Peak	348 46 10	47.3247

Azimuths and distances from Black Butte to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Pilot Butte	101 45 20	29.1795
Essex Mountain	163 06 03	29.9167
Wind River Peak	168 07 55	81.1561
West Atlantic Peak	171 28 31	74.2300
Atlantic Peak	172 00 51	73.7652
Yellow Butte	184 53 41	49.1669
Whisky Peak	230 13 19	81.8053
Seminole Peak	238 34 46	93.8326
Separation Peak	265 14 30	73.0016

Azimuths and distances from Yellow Butte to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Black Butte	4 57 02	49.1669
Essex Mountain	32 23 35	24.1008
Wyoming Peak	104 02 26	100.1618
Wind River Peak	145 35 51	36.9106
Atlantic Peak	149 04 54	28.0644
Whisky Peak	266 46 55	58.7687
Seminole Peak	270 06 12	75.8750
Cherokee Peak	293 05 34	78.1857
Separation Peak	302 06 32	80.8876

Azimuths and distances from Wind River Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Pilot Butte	8 57 53	74.4295
Medicine Butte	44 58 23	130.9820
Wyoming Peak	85 07 14	76.5424
Hoback Peak	111 01 19	77.6677
Grosventre Peak	125 43 02	68.4280
New Fork Peak	130 45 52	30.8889
Mount Bonneville	133 48 48	15.1240
Frémont's Peak	139 19 28	37.9811
Washakie Needle	177 03 31	71.8382
Seminole Peak	287 16 15	101.4509
Whisky Peak	288 34 25	84.0403
Separation Peak	309 08 12	115.6760
Atlantic Peak	314 28 40	9.0591
West Atlantic Peak	316 21 36	8.2752
Yellow Butte	325 19 15	36.9106
Black Butte	347 54 48	81.1561

Azimuths and distances from West Atlantic Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Pilot Butte	14 27 15	69.7145
Wind River Peak	136 26 19	8.2752
Whisky Peak	285 47 34	76.8151
Yellow Butte	327 57 10	28.7655
Black Butte	351 19 26	74.2300

Azimuths and distances from Pilot Butte to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Medicine Butte	76 33 15	83.2074
Wyoming Peak	135 51 11	93.1334
Frémont's Peak	172 31 18	103.1706
Wind River Peak	188 48 46	74.4295
West Atlantic Peak	194 13 16	69.7145
Atlantic Peak	194 54 03	69.5596
Essex Mountain	220 51 21	30.1534
Black Butte	281 23 20	29.1795

Azimuths and distances from east end of Bear River Valley base-line to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
South Hill	37 37 16	5.26907
West Base	92 11 33	1.93125
Soda Peak	93 25 20	11.42290
East Hill	193 02 38	1.78661

Azimuths and distances from west end of Bear River Valley base-line to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
South Hill	16 49 40	4.43804
Soda Peak	93 38 50	9.49212
North Hill	151 33 52	5.07885
East Hill	234 26 03	2.86720
Mount Preuss	245 22 10	6.44605
East Base	272 10 01	1.93125

Azimuths and distances from East Hill to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
East Base	15 02 58	1.78661
South Hill	31 28 29	6.93388
West Base	56 27 55	2.86720
Soda Peak	84 52 53	11.85307
North Hill	120 31 54	5.51364
Mount Preuss	253 55 12	3.67132

Azimuths and distances from South Hill to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Paris Peak	31 49 00	15.6100
Soda Peak	120 37 54	9.51761
North Hill	172 34 18	8.78752
West Base	196 48 39	4.43804
East Hill	211 25 37	6.93388
East Base	217 34 47	5.26907
Mount Preuss	225 50 19	9.95603
Lake View Peak	344 51 50	31.0722

Azimuths and distances from North Hill to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Paris Peak	17 52 28	23.0947
Soda Peak	61 16 05	8.04264
Mount Preuss	282 06 13	8.46704
East Hill	300 28 15	5.51364
West Base	331 32 06	5.07885
South Hill	352 33 24	8.78752

Azimuths and distances from Mount Preuss to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
North Logan Peak	28 38 08	45.8766
Paris Peak	37 21 56	25.3845
South Hill	45 55 58	9.95603
West Base	65 26 58	6.44605
East Hill	73 58 07	3.67132
Soda Peak	82 20 36	15.4732
North Hill	102 12 47	8.46704
Mount Putnam	124 26 02	56.3193
Caribou Mountain	175 36 27	41.4106
Mount Baird	187 24 02	60.4054
Grand Téton	194 33 35	88.9402
Hoback Peak	220 04 49	53.3383
Wyoming Peak	256 31 38	32.7850
Medicine Butte	347 19 15	80.8307
Lake View Peak	358 35 17	36.9430

Azimuths and distances from Soda Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Paris Peak	0 01 16	18.1137
North Logan	9 40 26	38.7779
Mount Putnam	137 15 19	46.0207
Caribou Mountain	195 28 12	45.0267
Grand Téton	202 56 56	95.8669
Hoback Peak	229 00 06	65.6200
North Hill	241 10 29	8.04264
Wyoming Peak	258 11 20	48.2040
Mount Preuss	262 08 26	15.4732
East Hill	264 43 31	11.85307
East Base	273 16 22	11.42290
West Base	273 31 20	9.49212
South Hill	300 31 25	9.51761
Lake View Peak	334 49 04	38.4687
Medicine Butte	336 29 50	83.6183

Azimuths and distances from Paris Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
North Logan Peak	17 56 05	21.1414
Mount Putnam	158 57 40	60.5778
Soda Peak	180 01 16	18.1137
North Hill	197 46 53	23.0947
Grand Téton	199 21 43	112.7702
South Hill	211 42 40	15.6100
Mount Preuss	217 09 48	25.3845
Wyoming Peak	239 20 09	54.8615
Lake View Peak	315 33 24	23.3902
Medicine Butte	330 20 23	67.3981

Azimuths and distances from Wyoming Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Willard Peak	39 13 59	109.9147
North Logan Peak	48 46 34	72.0881
Paris Peak	59 57 35	54.8615
Mount Preuss	76 57 00	32.7850
Soda Peak	78 48 51	48.2040
Mount Putnam	107 35 33	81.9928
Caribou Mountain	134 15 14	48.5916
Grand Téton	173 30 11	79.0212
Hoback Peak	184 39 52	33.2638
Grosventre Peak	203 00 38	50.8615
Frémont's Peak	234 33 01	62.4526
New Fork Peak	242 12 41	59.2193
Mount Bonneville	254 25 22	67.5224
Wind River Peak	264 06 26	76.5424
Yellow Butte	282 45 35	100.1618
Pilot Butte	315 00 07	93.1334

Azimuths and distances from Mount Putnam to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Sawtelle's Peak	197 43 24	116.9387
Grand Téton	231 07 57	87.6219
Mount Baird	242 01 19	61.0609
Caribou Mountain	257 04 05	44.2997
Hoback Peak	263 02 46	81.2946
Wyoming Peak	286 33 03	81.9928
Mount Preuss	303 48 36	56.3193
Soda Peak	316 50 06	46.0207
Paris Peak	328 32 58	60.5778
North Logan Peak	340 38 27	76.1431
Willard Peak	354 28 24	110.2500

Azimuths and distances from Caribou Mountain to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Soda Peak	15 37 53	45.0267
Mount Putnam	77 39 03	44.2997
Grand Téton	209 38 08	51.5591
Mount Baird	210 25 46	21.5962
Grosventre Peak	256 15 05	56.1869
Hoback Peak	270 41 06	37.5163
Wyoming Peak	313 47 10	48.5916
Mount Preuss	355 33 54	41.4106

Azimuths and distances from North Logan Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Ogden Peak	12 22 02	50.2688
Willard Peak	21 25 07	40.6216
Mount Putnam	160 57 55	76.1431
Soda Peak	189 35 21	38.7779
Paris Peak	197 51 01	21.1414
Grand Téton	199 03 08	133.9058
Mount Preuss	208 20 59	45.8766
Wyoming Peak	228 04 08	72.0881
Lake View Peak	261 25 52	23.1380
Medicine Butte	313 53 13	55.3868

Azimuths and distances from Medicine Butte to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Ogden Peak	78 34 50	51.8014
North Logan Peak	134 23 49	55.3868
Paris Peak	150 46 07	67.3981
Soda Peak	156 55 33	83.6183
Lake View Peak	158 21 19	45.1796
Mount Preuss	167 32 56	80.8307
Wind River Peak	223 46 50	130.9820
Pilot Butte	255 30 40	83.2074

Azimuths and distances from Ogden Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Ogden Observatory	103 14 49	6.0234
Willard Peak	160 02 34	11.9978
North Logan Peak	192 13 49	50.2688
Medicine Butte	257 56 16	51.8014

Azimuths and distances from Hoback Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Wyoming Peak	4 42 04	33.2638
Mount Preuss	40 32 30	53.3383
Soda Peak	49 40 01	65.6200
Mount Putnam	84 07 42	81.2946
Caribou Mountain	91 11 30	37.5163
Mount Baird	126 10 09	32.7097
Grand Téton	165 38 17	46.8308
Grosventre Peak	231 32 20	21.9468
Frémont's Peak	266 23 23	48.2687
New Fork Peak	276 24 09	49.9926
Mount Bonneville	283 35 01	64.1210
Wind River Peak	289 02 30	77.6677

Azimuths and distances from New Fork Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Wyoming Peak	62 54 52	59.2193
Hoback Peak	97 04 18	49.9926
Grosventre Peak	121 16 44	37.7565
Grand Téton	130 24 00	79.7018
Frémont's Peak	170 43 58	8.7446
Wind River Peak	310 26 53	30.8889

Azimuths and distances from Grosventre Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Wyoming Peak	23 16 45	50.8615
Hoback Peak	51 46 20	21.9468
Caribou Mountain	76 59 32	56.1869
Mount Baird	97 37 28	43.9557
Grand Téton	137 59 34	42.8420
Mount Sheridan	167 40 44	69.6232
Yount's Peak	200 31 44	51.6740
Washakie Needle	237 44 19	60.8395
Frémont's Peak	289 08 08	32.7521
New Fork Peak	300 50 37	37.7565
Mount Bonneville	302 41 16	53.4985
Wind River Peak	304 58 00	68.4280

Azimuths and distances from Frémont's Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Wyoming Peak	55 12 12	50.8615
Hoback Peak	87 00 58	48.2687
Grosventre Peak	109 31 22	32.7521
Grand Téton	125 55 07	73.0860
——— Peak	169 10 30	59.8085
Washakie Needle	205 46 58	47.8340
Wind River Peak	318 57 36	37.9811
Mount Bonneville	322 35 06	22.9730
New Fork Peak	350 40 54	8.7446
Pilot Butte	352 18 20	103.1706

Azimuths and distances from Grand Téton to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Mount Preuss	14 51 47	88.9402
North Logan Peak	19 38 38	133.9058
Paris Peak	19 52 09	112.7702
Soda Peak	23 27 26	95.8669
Caribou Mountain	29 59 01	51.5591
Mount Putnam	52 03 35	87.6219
Sawtelle's Peak	150 53 06	65.1538
Electric Peak	178 53 17	87.3273
Mount Washburn	193 57 06	75.2134
Mount Sheridan	200 29 44	38.7320
Index Peak	207 50 32	96.7400
Yount's Peak	250 06 48	49.6353
Frémont's Peak	305 08 02	73.0860
New Fork Peak	309 33 53	79.7018
Grosventre Peak	317 35 45	42.8420
Hoback Peak	345 28 34	46.8308
Wyoming Peak	353 22 46	79.0212

Azimuths and distances from Mount Sheridan to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Grand Téton	20 41 03	38.7320
Sawtelle's Peak	114 42 19	49.7465
Mount Hilgard	134 43 49	64.2333
Electric Peak	163 32 06	53.2639
Mount Washburn	187 17 20	36.9970
Index Peak	212 53 04	58.5345
Yount's Peak	300 32 47	38.3759
Grosventre Peak	347 28 04	69.6232

Azimuths and distances from Sawtelle's Peak to—

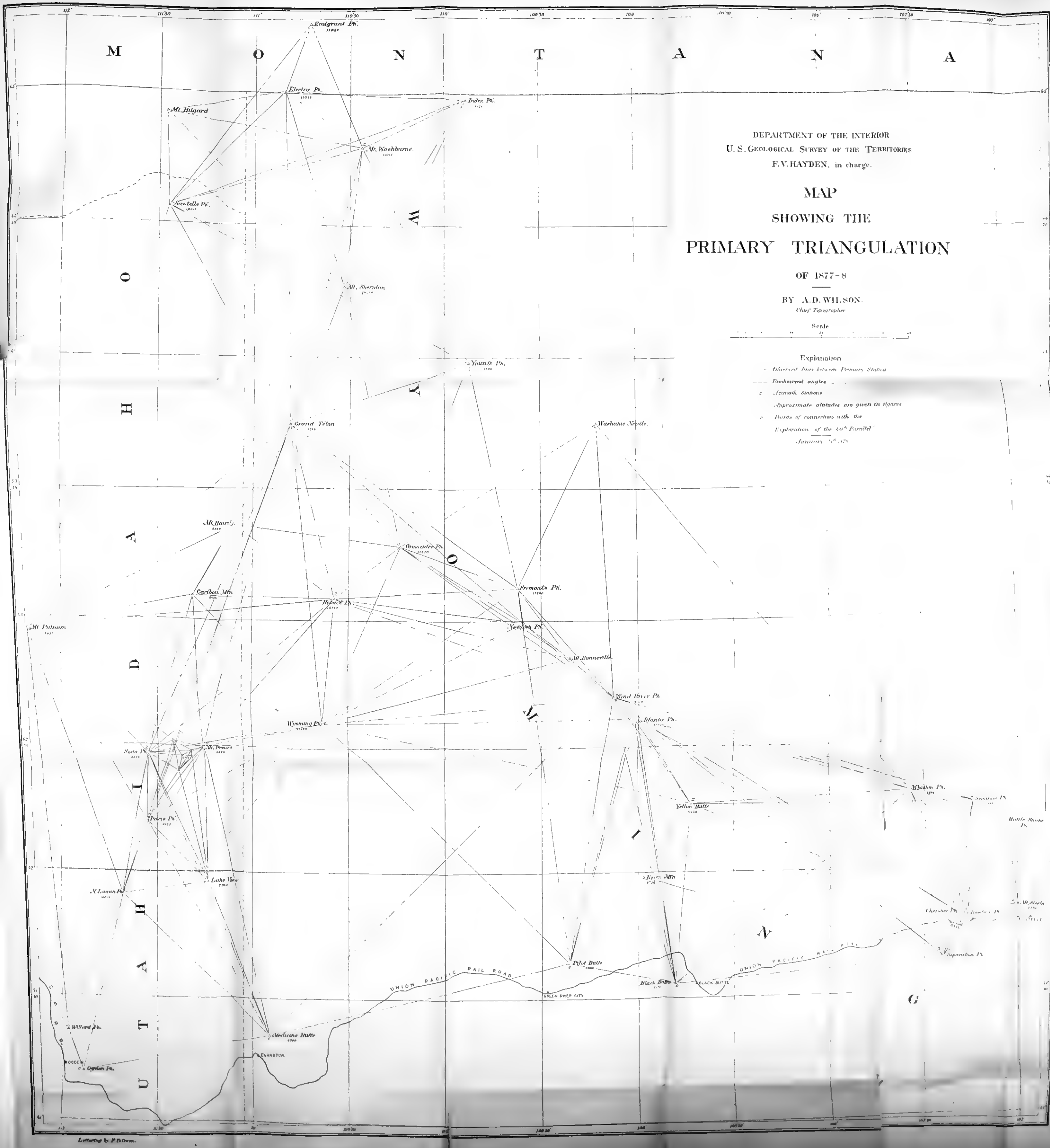
Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Mount Putnam	18 12 27	116.9387
Mount Hilgard	178 19 23	24.4162
Emigrant Peak	216 35 35	60.3740
Electric Peak	224 10 22	42.6972
Index Peak	249 07 33	82.0330
Mount Washburn	251 40 23	52.3610
Mount Sheridan	294 03 52	49.7465
Yount's Peak	296 36 29	88.0099
Grand Téton	330 26 11	65.1538

Azimuths and distances from Mount Washburn to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Mount Sheridan	7 21 21	36.9970
Grand Téton	14 12 34	75.2134
Sawtelle's Peak	72 23 02	52.3610
Mount Hilgard	99 39 47	51.0406
Electric Peak	126 04 25	24.4660
Emigrant Peak	157 31 13	34.8233
Index Peak	245 22 05	29.8141
Yount's Peak	333 17 36	62.9494

Azimuths and distances from Electric Peak to—

Names of stations.	Azimuths.	Distances.
	° ′ ″	*Miles.*
Sawtelle's Peak	44 36 06	42.6972
Mount Hilgard	78 54 08	31.0930
Emigrant Peak	199 41 57	18.9106
Index Peak	272 08 14	46.9188
Mount Washburn	305 47 24	24.4660
Mount Sheridan	343 19 00	53.2639
Grand Téton	358 51 20	87.5937



Lettering by F.D. Owen.

REPORT OF HENRY GANNETT, M. E., TOPOGRAPHER.

LETTER OF TRANSMITTAL.

WASHINGTON, D. C., *January* 21, 1879.

SIR: I have the honor to transmit to you herewith a short report on the geographical work of the Green River division during the field season of 1877.

The party, consisting of seven men, left Green River City, Wyo., on June 1, and commenced work almost immediately. They continued work until the end of September, losing but one day during the season from bad weather.

The season was an eminently successful one, and this success is due in no small part to my assistant, Mr. J. E. Mushbach, who worked throughout with his customary ability and care.

As in previous years, my thanks are due to Dr. A. C. Peale, the geologist of my party, for his assistance in my own work.

With high respect, I am, very truly, yours,

HENRY GANNETT.

Dr. F. V. HAYDEN,
United States Geologist.

REPORT OF HENRY GANNETT, M. E.

CHAPTER I.

METHODS OF WORK.

The area assigned to the Green River division for survey during the season of 1877 was approximately a rectangle, limited in longitude by the meridians of 109° 30′ and 112° 00′, and in latitude by the parallels of 41° 45′ and 43° 00′, embracing parts of Wyoming, Idaho, and Utah. The area of this "rectangle" is about 11,000 square miles. This district was surveyed, and then, the season not being ended, the work was continued westward to the meridian of 112° 30′, making the total area surveyed during the season about 13,000 square miles. One hundred and forty-seven stations were made with the gradienter, besides about two hundred minor stations and locations. The number of horizontal angles measured was 9,200; of vertical angles (for relative height), 1,960.

METHODS OF SURVEY.

As a basis for the secondary triangulation and topographical work, twelve points, fairly distributed, were established by the primary triangulation within or near the district assigned me. The secondary triangulation was carried on by myself in connection with the topographical work, the instrument used being the "gradienter," a compact, strong, theodolite, reading to minutes. With this instrument twenty-two secondary stations were located by closed triangles, while the other stations were established by incomplete triangles and the "three-point problem."

To illustrate the character of the secondary triangulation, the following triangles, with their summing up, are presented. The asterisk after the name of a station indicates a primary station.

	Angle.
Soda Peak*	25°13′
Station 108	19 14
Paris Peak*	135 35
	180 02

Soda Peak*	100 30
Paris Peak*	41 28
Snow Mountain	38 08
	180 06

[a]Station 79 is the point established by this triangle.

	Angle.
Soda Peak*	80°05′
Paris Peak*	56 01
Station 133	43 58
	180 04
Soda Peak*	20 25
Snow Mountain	96 26
Station 133	63 09
	180 00
Soda Peak*	75 29
Station 97	57 34
Paris Peak*	46 57
	180 00
Paris Peak*	23 18
Station 55*	21 02
Station 38	135 32
	179 52
Paris Peak*	42 26
Mount Preuss*	74 33
Station 38	59 57
	179 56
Mount Preuss*	66 19
Station 55*	38 03
Station 38	75 35
	179 57
Station 135	20 16
Station 133	110 02
Snow Mountain	49 45
	180 03
Station 132	83 35
Station 133	51 43
Station 135	44 39
	179 57
Station 133	91 08
Paris Peak*	24 32
Station 132	64 20
	180 00

	Angle.
Station 76	57° 44′
Snow Mountain	78 20
Station 135	44 01
	180 05
Station 76	23 58
Station 132	47 09
Station 135	108 56
	180 03
Soda Peak*	20 38
Snow Mountain	135 29
Station 76	23 52
	179 59
Station 119	32 41
Station 132	69 42
Station 133	77 41
	180 04
Soda Peak*	50 01
Station 96	86 17
Station 97	43 42
	180 00
Soda Peak*	90 46
Snow Mountain	59 54
Station 121	29 23
	180 03
Soda Peak*	26 25
Snow Mountain	55 29
Station 117	98 06
	180 00
Snow Mountain	40 57
Station 133	80 09
Station 117	58 54
	180 00
Station 76	80 42
Station 132	22 08
Station 77	77 12
	180 02

	Angle.
Snow Mountain	26°21′
Station 76	114 28
Station 77	39 13
	180 02
Station 135	26 52
Station 132	127 21
Station 129	25 43
	179 56
Station 132	14 03
Station 77	126 11
Station 79 [a]	39 47
	180 01
Station 76	20. 22
Station 77	84. 17
Station 78 [b]	75. 13
	179. 52
Station 74	37. 55
Station 76	97. 51
Station 77	44. 24
	180. 10
Station 73	43. 48
Station 66	80. 21
Soda Peak	55. 55
	180. 04
Gunsight Mountain	77. 30
Station 132	51. 40
Station 121	50. 58
	180. 08
Station 132	45. 05
Gunsight Mountain	98. 09
Logan Peak*	36. 45
	179. 59

The mean error of summing up of the above twenty-eight triangles is three minutes, or one minute to each angle.

The triangles were corrected by distributing the errors among the angles, taking due account of the circumstances connected with the measurements at the different stations. On all these stations monu-

[a] Station 79 is the point established by this triangle.
[b] Station 78 is the point established by this triangle.

ments of stone, 5 feet in height, were erected at the time of occupation. Previous to occupation the natural summit of the station was sighted.

The topography was secured as usual by map and perspective sketches. The former form the basis of the map. They were made by eye on an assumed scale, the distances and directions being estimated. The assumed scale of these sketches was one mile to an inch. In transferring these sketches to the map in the office, their inaccuracies are corrected by the exact location of all important points, as mountain peaks, buttes, angles of plateau, mouths and bends of streams, &c. In the area surveyed this season (13,000 square miles), about 1,000 points, besides the 350 stations and substations, were located by intersections of sight-lines, making, with the stations, a located point in every 10 square miles.

Elevations were measured by the mercurial barometer, aneroids, and the vertical arc of the gradienter. During the season, base barometric observations were taken at the adjutant's office at Fort Hall, Idaho. The height of this point was determined by the computation of coincident barometric observations for four months at this point and Corinne, Utah. Through the kindness of the Chief Signal Officer of the Army, the barometric observations at Salt Lake City also were furnished me for use as base observations.

The heights of the camps, where more or less extended series of observations were taken, were determined by direct reference to the base stations. The camps ranged in height from 4,500 to 7,000 feet, only one or two exceeding the latter height; hence in these cases there was little room for error due to the defects in the barometric formula. The heights of stations were determined by barometric reference to the camps at their bases, and by vertical angles with the gradienter from them, and, in addition, the stations were connected with one another by a complex system of vertical angles, in such a way that their *relative* heights were known, and thus all barometric measurements were reduced to a common point, so that the height of each station was a mean of all barometric measurements of stations. The heights of all located points were measured by dip angles. The heights of points of minor importance were measured by aneroids, and referred for computation to the nearest camp. Aneroids were compared, every morning and evening, with the mercurial barometer.

From the perspective sketches, aided by these measured heights (which number in the aggregate more than 1,500), the distribution on the map, of contours 200 feet apart vertically, has been effected with a considerable approach to accuracy.

CHAPTER II.

LATITUDES, LONGITUDES, AND ELEVATIONS ABOVE SEA-LEVEL.

TABLE I.—*Towns, &c.*

	Latitude.		Longitude.		Elevation.
	°	′	°	′	*Feet.*
Bennington, Idaho	42	22	111	18	*a*5, 708
Black Rock, Idaho	42	48	112	19	5, 500
Bloomington, Idaho	42	11	111	25	*a*5, 985
Carpenter's Station, Idaho					*a*4 666
Clarkson, Utah	41	54	112	03	4, 800
Clifton, Idaho	42	13	112	02	*a*4, 893
Fish Haven, Idaho	42	02	111	24	*a*5, 932
Fort Hall, Idaho					4, 783
Franklin, Idaho	42	01	111	49	*b*4, 516
Georgetown, Idaho	42	28	111	22	5, 800
Hampton's Bridge, Utah	41	47	112	07	*a*4, 300
Hyde Park, Utah	41	48	111	50	4, 500
Keeney's Stage Station, Idaho					*a*4, 933
Laketown, Utah	41	50	111	20	*a*6, 000
Liberty, Idaho	42	19	111	28	6, 060
Logan, Utah	41	44	111	51	*b*4, 509
Malade City, Idaho	42	11	112	16	*a*4, 700
Meadowville, Utah	41	50	111	24	6, 200
Montpelier, Idaho	42	20	111	17	*a*5, 793
Morristown, Idaho	42	39	111	37	5, 700
Newton, Utah	41	51	112	00	*a*4, 500
Oneida, Idaho					5, 700
Oneida Salt Works, Idaho	42	48	111	05	6, 300
Ovid, Idaho	42	17	111	24	*a*5, 760
Oxford, Idaho	42	16	112	01	*a*4, 862
Packer's Bridge, Idaho	42	07	111	57	4, 500
Paris, Idaho	42	13	111	25	*a*5, 836
Plymouth, Utah	41	52	112	10	4, 500
Pocatello Stage Station, Idaho					*a*4, 512
Portage, Utah	41	58	112	15	4, 700
Red Rock Ranch, Idaho	42	36	112	03	*b*4, 792
Richmond, Utah	41	55	111	50	*b*4, 537
Ross Fork, Idaho					*a*4, 394
Saint Charles, Idaho	42	07	111	23	*a*5, 932
Samaria, Idaho	42	07	112	20	4, 800
Smithfield, Utah	41	50	111	50	*b*4, 565
Soda Springs, Idaho	42	39	111	36	*b*5, 779
Weston, Idaho	42	02	112	00	4, 600

a Authority is Hayden's Report for 1871 or 1872. *b* Authority is railroad levels.

TABLE II.—*Mountains.*

	Latitude.			Longitude.			Elevation.
WYOMING RANGE, WYOMING.	°	′	″	°	′	″	*Feet.*
13—45	42	25	20	110	39	30	9, 940
Station 46		29	20		30	00	9, 959
23—46		30	20		34	10	10, 575
1—a		30	20		42	20	9, 839
Station 47		30	30		26	10	10, 043
21—45		30	40		38	00	10, 039
24—45		31	30		34	00	9, 925
1—48		32	30		37	20	10, 776
2—48		32	50		37	20	10, 990
3—48		33	20		37	20	10, 972

TABLE II.—*Mountains*—Continued.

	Latitude.			Longitude.			Elevation.
WYOMING RANGE, WYOMING—Continued.	°	′	″	°	′	″	*Feet.*
4—48	42	34	30	110	37	20	10,972
5—48		34	40		38	30	10,910
Station 48		35	10		33	40	10,972
6—48		35	10		38	15	11,056
26—46		35	20		33	20	10,838
27—46		35	30		33	00	10,716
Cone No. 4		35	30		38	00	11,364
7—48		36	00		36	40	10,907
8—48		36	00		36	10	10,999
9—48		36	15		35	30	11,132
Station 55 (Wyoming Peak)		36	15		37	40	11,490
Coffin Mountain		36	30		38	00	11,376
10—48		37	15		34	00	10,417
11—48		37	15		34	20	10,648
12—48		37	30		35	15	10,910
13—48		37	30		36	05	10,662
17—48		37	40		38	15	19,972
39—48		38	15		32	50	10,318
37—48		39	45		32	40	10,324
26—48		40	50		36	10	10,622
31—48		42	50		34	30	10,871
35—48		42	50		33	30	10,812
44—49		42	55		38	30	11,056
34—48		43	25		33	30	10,823
30—48		43	30		35	20	11,035
29—48		43	45		36	30	11,076
50—49		44	20		38	30	10,976
58—49		46	00		38	30	10,904
65—49		46	45		38	30	10,576
Volcanic Cone		47	00		33	00	10,583
33—48		47	00		34	30	11,234
70—49		47	10		38	40	10,576
Station 49		47	20		34	45	11,276
8—50		47	40		35	15	11,147
79—49		48	00		39	00	10,926
Station 54		49	00		39	00	10,679
10—50		51	15		35	45	10,966
11—50		51	40		35	45	10,857
12—50		52	20		36	00	10,835
94—49		52	20		39	10	9,841
Station 52		53	00		36	15	10,899
26—53		53	30		39	00	10,244
15—50		53	50		37	00	10,451
17—50		54	30		37	40	10,446
Station 53		55	10		40	20	9,628
22—50		57	00		33	40	10,366
21—50		57	30		34	10	10,416
26—50		57	30		31	00	10,386
23—50		57	55		33	00	10,456
24—50		58	00		32	40	10,490
25—50		58	10		31	20	10,411
19—50	43	00	15		40	15	10,535
SALT RIVER RANGE, WYOMING.							
Station 45	42	29	20		35	45	9,855
25—44		34	00		47	20	10,131
5—44		34	00		45	00	9,899
35—38		35	00		48	30	10,809
Cone No. 2		36	00		46	00	10,757
Cone No. 1		36	30		45	00	10,874
50—58		38	00		47	00	10,169
4—55		38	10		46	40	10,572
5—55		38	50		46	30	10,494
10—58		39	00		51	00	10,441
27—58		39	20		52	45	9,967
8—58		39	45		50	40	10,444
8—55		39	50		50	45	10,590
26—58		40	00		52	15	9,863
7—58		40	20		47	15	10,529
5—58		40	30		48	20	10,263
11—58		40	40		47	20	10,518
13—58		40	50		47	25	10,988
14—58		41	30		47	30	10,871
7—55		41	40		47	35	10,652
1—54		42	30		47	00	10,796
Station 58		43	00		51	20	10,158
16—58		43	15		47	00	10,903
71—53		43	50		47	00	10,865

TABLE II.—*Mountains*—Continued.

	Latitude.			Longitude.			Elevation.
SALT RIVER RANGE, WYOMING—Continued.	°	′	″	°	′	″	*Feet.*
4—54	42	44	15	110	46	50	10, 696
5—54		44	50		47	10	10, 890
8—54		46	20		47	20	10, 783
11—56		46	40		51	20	9, 785
21—58		46	55		48	20	10, 971
12—56		47	00		51	00	10, 084
14—56		47	00		52	10	9, 654
13—56		47	30		52	10	9, 872
22—58		47	30		48	20	10, 846
33—53		48	30		45	40	10, 850
75—53		48	50		48	30	10, 592
76—53		49	20		48	30	10, 711
Station 56		49	50		48	50	10, 548
34—53		50	00		46	00	9, 800
35—53		50	20		46	15	9, 990
36—53		50	50		46	40	9, 983
25—56		51	00		49	00	9, 968
37—53		51	10		47	00	10, 027
38—53		51	40		47	15	10, 400
39—53		52	15		47	30	10, 105
28—56		52	40		50	20	9, 642
40—53		52	40		47	30	10, 057
29—56		52	45		51	20	9, 325
41—53		53	10		47	30	10, 054
30—56		53	15		52	30	9, 872
43—53		54	15		48	00	10, 028
12—53		54	40		48	10	10, 036
13—53		55	00		48	20	10, 116
31—56		55	30		53	20	9, 830
32—56		55	30		52	30	10, 000
33—56		55	30		52	00	10, 307
Virginia Peak		55	45		47	45	10, 044
35—56		56	50		51	30	10, 228
39—56		57	00		48	50	10, 143
36—56		57	10		51	10	10, 028
43—56		57	10		51	10	10, 266
38—56		57	20		49	15	10, 090
19—53		57	45		49	30	10, 518
34½—57		59	30		56	20	9, 044
32—57		59	50		54	55	10, 108
Station 57	43	00	10		55	10	10, 200
133—57		00	30		56	45	9, 490
RANGE WEST OF SALT RIVER, IDAHO.							
Station 99	42	18	50	111	13	00	7, 856
28—93		23	40		15	40	8, 943
Station 97		24	10		15	20	9, 271
26—93		24	20		15	10	9, 249
25—93		27	00		16	40	9, 213
24—93		27	40		17	10	9, 220
9—60		27	50		8	00	8, 824
8—60		28	40		7	50	8, 824
Mount Preuss		29	42		15	11	9, 979
Georgetown Peak		30	30		19	00	8, 466
Station 96		34	15		15	20	8, 086
29—69		39	30		19	00	7, 707
28—69		41	20		19	40	7, 719
30—69		42	10		15	30	8, 905
27—69		43	20		20	50	7, 600
36—69		43	20		24	00	6, 978
35—69		44	30		24	40	7, 141
26—69		44	50		23	10	7, 492
25—69		45	30		23	30	7, 428
BEAR RIVER RANGE, UTAH AND IDAHO.							
South Logan Peak	41	43	00		43	15	
11—124		45	15		46	20	7, 483
Station 124		47	20		45	20	8, 013
Station 125		47	30		38	30	7, 394
10—111		47	30		42	00	8, 987
5—123		49	00		43	00	10, 147
Station 111		49	30		32	20	8, 710
17—124		49	40		44	00	7, 349
27—122		50	20		43	30	9. 714
14—123		50	20		38	20	9, 014
2—123		50	40		42	00	9, 724
26—122		50	45		43	30	9, 561

TABLE II.—*Mountains*—Continued.

	Latitude.			Longitude.			Elevation.
BEAR RIVER RANGE, UTAH AND IDAHO—Continued.	°	′	″	°	′	″	*Feet.*
1—123	41	51	55	111	41	45	9,838
11—123		52	00		42	20	9,104
13—123		53	30		40	20	9,618
24—123		53	40		43	45	9,063
18—122		54	30		43	30	9,370
Logan Peak		54	39		40	46	10,004
2—121		55	00		42	05	9,858
16—123		55	40		40	40	9,844
2—120		56	20		42	45	9,787
4—120		56	40		43	00	9,521
7—112		57	00		34	00	8,625
17—121		57	00		38	15	9,453
Station 121		58	10		40	10	9,905
1—121		58	15		40	10	9,451
Station 112		58	30		28	30	9,137
9—121	42	00	00		41	20	9,094
7—121		00	10		42	15	8,649
7—108		00	40		28	45	9,203
12—121		00	50		39	30	9,663
47—131		01	45		41	30	8,643
10—113		02	05		39	20	8,424
11—113		02	30		39	30	8,321
12—113		04	00		39	00	8,950
13—113		05	00		39	00	8,794
Station 113		05	30		35	10	9,450
45—131		06	40		36	00	9,221
23—113		07	50		33	30	9,255
25—113		08	20		34	10	9,195
22—113		09	30		34	40	8,974
21—113		09	50		35	20	9,274
Lone Cone		10	00		35	45	9,246
41—131		11	00		34	30	9,323
6—114		11	00		35	05	8,614
7—114		11	10		36	00	8,792
Station 119		11	10		46	00	7,832
8—114		11	15		37	00	8,983
Paris Peak		12	09		33	12	9,522
43—131		12	40		34	00	9,266
42—131		13	45		35	00	9,286
12—114		16	15		34	00	9,213
40—130		17	00		34	00	9,070
5—116		17	30		39	30	7,752
8—116		19	00		44	45	9,222
17—114		19	30		33	30	8,786
Station 118		20	50		33	20	8,522
Soda Peak		27	54		33	11	9,683
North Soda Peak		28	10		33	10	9,413
"Next"		31	25		37	45	8,909
Station 91		33	40		38	05	8,554
Sheep Rock		38	30		42	30	....
SODA SPRING HILLS, IDAHO.							
Station 88		40	15		47	00	6,630
8—69		40	15		40	15	7,050
9—69		40	30		40	30	7,086
11—69		41	40		39	40	7,042
12—69		41	40		38	30	6,814
13—69		42	20		39	20	6,930
Station 87		43	10		39	40	6,904
15—69		44	20		44	20	7,220
4—C		45	15		44	50	7,540
3—C		46	10		46	30	7,037
2—C		46	45		46	45	6,970
Station 82		47	30		48	00	6,935
Station 75		53	40		56	30	6,709
BETWEEN THE UPPER VALLEY OF THE BEAR RIVER AND BEAR LAKE, UTAH AND IDAHO.							
Station 109	41	47	15		20	30	7,211
Station 110		48	10		17	50	7,476
Station 107		51	20		6	40	7,181
Station 105		56	45		3	05	7,170
Station 108 (Lake View Peak)		57	36		14	07	7,795
7—103		59	00		2	50	....
Station 104	42	00	15		2	20	7,800
29—100		00	45		2	30	....
4—103		1	30		1	15	7,643

TABLE II.—*Mountains*—Continued.

	Latitude.			Longitude.			Elevation.
BETWEEN THE UPPER VALLEY OF THE BEAR RIVER AND BEAR LAKE, UTAH AND IDAHO—Continued.	°	′	″	°	′	″	*Feet.*
3—103	42	2	20	111	1	20	7,649
Station 103		2	45		4	30	7,798
2—103		3	40		1	00	7,577
1—103		3	45		1	45	7,550
Station 102		7	20		4	15	7,606
Station 100		7	50		14	10	7,092
PORTNEUF RANGE, IDAHO.							
Station 131		17	44		54	40	6,550
Red Rock (in the gap)		21	30	112	02	40	5,376
Station 117		23	45	111	51	30	8,029
Station 133		24	30		58	00	8,008
Marsh Cone		26	10	112	00	00	7,663
20—133		27	45	111	58	30	7,883
17—133		27	50	112	01	20	7,743
18—133		28	30		1	30	7,712
19—133		29	20	111	59	30	7,858
Snow Mountain		30	45		55	40	9,269
19—83		32	30		54	00	7,259
18—83		32	40		53	00	7,615
17—83		33	15		54	00	7,579
15—83		34	00		54	10	7,526
Station 83		34	15		57	40	7,896
14—83		34	20		54	30	7,426
12—83		34	30		55	00	7,442
10—83		34	40		54	00	7,588
9—83		35	00		54	00	7,579
38—83		35	00	112	04	30	7,131
47—76		35	30		4	50	7,156
8—83		35	40	111	54	00	7,302
6—83		35	40		56	40	6,290
5—83		35	40		56	00	6,690
4—83		36	15		55	00	6,638
3—83		36	40		55	15	6,384
2—83		37	00		55	30	6,953
1—83		37	30		56	00	7,006
49—76		38	00		57	10	7,483
50—76		38	30		57	10	7,830
51—76		39	00		57	20	8,125
53—76		40	00		58	10	7,762
54—76		40	45		59	45	7,311
52—76		40	45		58	00	7,635
Station 76		42	45	112	07	00	9,115
21—75		44	00		7	50	9,136
20—75		44	20		7	00	8,839
22—75		45	00		8	20	9,250
23—75		45	45		8	20	9,437
24—75		46	00		8	30	9,144
25—75		46	30		8	20	9,859
Station 79		50	00		14	00	6,311
Station 80		50	50		22	00	6,923
Station 74		54	30		7	50	9,063
Station 73 (Mount Putnam)		57	11		10	09	8,933
Station 72		57	50		2	00	6,772
MALADE RANGE, BETWEEN CACHE AND MALADE VALLEYS, UTAH AND IDAHO.							
South gate of Bear River	41	50	00		03	00	5,690
Station 126 (north gate of Bear River)		50	30		03	15	5,532
6—127		53	30		6	45	7,456
Station 127 (Gunsight Mountain)		55	20		8	10	8,306
Station 128		59	15		9	00	6,895
d—128	42	00	00		10	40	7,306
b—128		3	45		9	50	7,085
Station 129		4	00		7	05	7,131
36—130		7	15		4	40	6,229
Station 130		8	45		5	00	8,395
39—130		9	40		5	00	8,200
36—131		11	10		4	40	7,868
38—130		11	30		4	00	8,607
Long Cone		14	00		5	00	8,805
29—132		15	40		6	10	9,332
Station 132 (East Malade Mountain)		16	00		6	15	9,332
28—132		16	20		5	00	9,244

TABLE II.—*Mountains*—Continued.

	Latitude.			Longitude.			Elevation.
BANNACK RANGE, IDAHO.	°	′	″	°	′	″	*Feet.*
West Malade Mountain	42	20	00	112	20	00	9,220
Station 135		23	30		17	50	8,931
29—73		36	50		19	30	8,739
Station 78		37	15		19	30	8,783
31—73		37	45		19	30	8,681
32—73		39	45		19	30	8,065
33—73		40	00		20	50	8,687
35—73		40	45		21	00	8,763
Station 77		40	50		21	00	8,764
37—73		41	50		19	40	8,087
17—76		44	45		21	00	7,380

TABLE III.—*Height of the timber line.*

	Latitude.			Elevation.
	°	′	″	*Feet.*
On Station 48, Wyoming Range	42	35	10	10,700
On Station 55, Wyoming Range		36	15	11,160
On Station 56, Salt River Range		49	50	10,170
On Station 52, Wyoming Range		53	00	10,900
On Station 57, Salt River Range	43	00	10	10,000

The limit of timber in the Salt River Range seems to be abnormally low. In the Wyoming Range it agrees quite closely with the hight in other ranges in the same latitude.

No peaks in the Bear River Range are above the limit of timber, and the peaks in the other ranges in this rectangle do not reach it.

TABLE IV.—*Divides and passes.*

Thompson's Pass, Wyoming Range, Wyoming	8,686
McDougal's Pass, Salt River Range, Wyoming	9,300
McDougal's Gap, Wyoming Range, Wyoming	8,343
Divide on Lander's road from Smith's Fork of Bear River to Labarge Creek, Wyoming	8,872
Divide between Crow and Smoking Creeks, Idaho	6,890
Divide on Lander's road between Smoking Creek and Blackfoot River, Idaho	7,255
Divide on Lander's road between Blackfoot River and John Day's Lake, Idaho	6,800
Divide on Lander's road between Blackfoot and Portneuf Rivers, Idaho	6,149
Divide between the Upper Portneuf and Ross Fork, Idaho	6,430
Divide on the trail from Laketown to Logan, over the Bear River Range, Utah	7,130
Divide on the trail from Bloomington to Franklin, Idaho, over the Bear River Range	8,830
Divide on the road from Ovid to Gentile Valley, Idaho, over the Bear River Range	7,329
Malade Divide	5,690
Red Rock Gap (railroad levels)	4,792
Divide between the Bear and Blackfoot Rivers, north of Soda Springs (railroad levels)	6,210

TABLE V.—*Approximate latitudes, longitudes, and elevations of important stream junctions.*

	Latitude.			Longitude.			Elevation.
	°	′	″	°	′	″	*Feet.*
Mouth of Little Sandy Creek	42	06	00	109	27	30	6,519
Mouth of Big Sandy River	41	50	30	109	48	00	6,240
Mouth of Slate Creek	42	00	00	110	02	00	6,500
Mouth of Fontenelle Creek	42	04	30	110	08	30	6,620
Mouth of Labarge Creek	42	13	00	110	09	30	6,650
Mouth of Piney Creek	42	31	30	110	04	30	6,815
Mouth of Bitterroot Creek	42	31	40	110	04	20	6,820
Mouth of White Clay Creek	42	31	45	110	04	00	6,825
Mouth of Feather Creek	42	24	00	110	05	30	6,686
Mouth of Marsh Creek	42	41	00	109	59	00	6,976
Mouth of Horse Creek	42	52	20	110	03	30	7,180
Mouth of Lead Creek	42	59	20	110	08	00	7,383
Mouth of New Fork of the Green	42	34	00	109	58	30	6,900
Mouth of Willow Creek	42	51	00	111	55	00	5,450
Mouth of Smith's Fork	42	05	20	110	59	00	6,223
Mouth of Thomas' Fork	42	12	20	111	04	30	6,125
Mouth of Twin Creek (Upper)	41	48	40	111	03	45	6,300
Mouth of Twin Creek (Lower)	42	27	50	111	24	00	5,939
Mouth of Crow Creek	42	43	40	110	58	40	6,313
Mouth of South Fork of Blackfoot River	42	45	45	111	25	30	6,350
Mouth of Little Blackfoot River	42	54	00	111	37	00	6,100
Mouth of Cub River	41	53	40	111	53	20	4,425
Mouth of Logan Fork	41	48	00	111	58	00	4,375
Mouth of Blacksmith's Fork	41	43	00	111	52	30	4,500
Mouth of Marsh Creek	42	46	30	112	14	00	4,600
Mouth of Deep Creek	42	07	15	111	56	30	4,480
Mouth of High Creek	41	56	30	111	50	00	4,500
Mouth of Muddy Creek	41	44	00	111	57	00	4,400
Mouth of John Day's River	43	10	00	111	01	00	5,400
Mouth of Salt River	43	10	00	111	04	00	5,383
Mouth of Glacier Creek	42	53	00	111	50	00	5,800
Mouth of McDougal's Creek	42	52	00	110	43	00	6,761
Mouth of Smoking Creek	41	48	00	111	00	00	6,000
Mouth of Little Malade River	42	07	00	112	18	00	4,625
Mouth of Mill Creek	42	05	00	112	16	00	4,600
Mouth of Devil Creek	42	05	00	112	17	00	4,600
Mouth of Battle Creek	42	08	30	111	55	00	4,498

TABLE VI.—*Slopes of streams.*

	From mouth of Big Sandy.	Elevation.	Fall per mile.
GREEN RIVER.	*Miles.*	*Feet.*	*Feet.*
Mouth of Lead Creek	111	7,383	....
Bend	105	7,280	17.2
	90	7,036	16.3
Mouth of New Fork	74	6,900	8.5
Mouth of Piney Creek	68	6,815	14.2
Mouth of Feather Creek	58	6,686	12.9
Mouth of Fontenelle Creek	29	6,620	2.3
	11	6,366	14.6
Mouth of Big Sandy River	0	6,240	11.5
BEAR RIVER.	*Miles from mouth.*		
At Evanston, Wyo	255	....	....
	253	6,776 R. R.	135.5
Bend	251	6,505 R. R.	19.0
	243	6,353 R. R.	3.7
	216	6,254	2.1
Mouth of Smith's Fork	201	6,223 R. R.	8.7
	177	6,015 R. R.	15.0
	176	6,000 R. R.	2.2
Foot of cañon (enter Bear Lake Valley)	171	5,989	4.3
	155	5,920 R. R.	....
	153	5,913 R. R.	3.5
	151	5,900 R. R.	6.5
Soda Springs, Idaho	125	5,855 R. R.	1.6
Bend below Sheep Rock	113	5,737	9.8
Next Bend	108	5,522 R. R.	43.0
Head of cañon at foot of Gentile Valley	88	4,692 R. R.	41.5
Foot of cañon at foot of Gentile Valley	73	4,609 R. R.	5.5
Mouth of Battle Creek	66	4,499	16.7
Head of Gates	30	4,450	1.6
Hampton's Bridge	24	4,353	16.2
Mouth	0	4,218 R. R.	5.6

(R. R. signifies that the heights are the results of railroad levels.)

TABLE VI.—*Slopes of streams*—Continued.

	From mouth of Big Sandy.	Elevation.	Fall per mile.
JOHN DAY'S RIVER.	*Miles from mouth.*	*Feet.*	*Feet.*
	53	7,783	....
	44	7,337	49.6
Mouth of McDougal's Creek	31	6,761	52.0
Mouth	0	5,400	44.0
SALT RIVER.			
Its mean fall per mile from the mouth of Crow Creek to its mouth is 24.5 feet.			
BLACKFOOT RIVER.	*Miles.*		
First crossing of Lander's road, near head of stream	57	6,850	....
	49	6,550	37.5
	32	6,266	17.0
Second crossing of Lander's road	12	6,069	9.6
Where Lander's road finally leaves	0	5,600	39.1
PORTNEUF RIVER.	*Miles from preceding.*		
Crossing of Lander's road	....	5,760	....
	5	5,470	58.0
	12	5,367	8.6
Head of bend	14	5,086	20.1
Foot of lower bend (enter Snake River Plains)	31	4,565	16.8

Most of the above latitudes and longitudes are approximate, having been scaled off from the map.

CHAPTER III.

PHYSICAL FEATURES.

The district is drained by the Green, Snake, and Bear Rivers and their branches. The areas drained respectively by these three streams are as follows: Green River, 5,223 square miles; Bear River, 4,898 square miles; and the Snake, 2,879 square miles.

The area is characterized by broad meridional valleys, separated by short, mainly simple mountain ranges. There is a very noticeable absence of timber; it is only on the slopes of the higher mountain ranges that any is found, while not only the valleys but the hills and many of the mountain ranges, especially in the western part, are treeless. The Wyoming, Salt River, and Bear River Ranges comprise practically all the timbered areas. There is abundant pasturage of the best quality, not only in the valleys, but over the hills and the minor mountain ranges. Except in the case of the Green River Basin, where all the waters cannot be used, the amount of arable land is measured by the quantity of water available for irrigation.

On Smoking Creek, a large western branch of Salt River, are extensive deposits of salt, to which the river owes its names.

DRAINAGE AREA OF GREEN RIVER.

Green River, one of the forks of the Colorado of the West, rises in the western slopes of the Wind River Mountains, near Union Pass, and pursues a general southerly course to its junction with the Grand. It flows from north to south, in general course, across the district under consideration, in a broad valley known as the Green River Basin. Of that portion of its drainage area with which we are here concerned, this basin forms the larger part, though the tributaries of Green River extend some distance into the mountains on either side.

THE GREEN RIVER BASIN.

Extending from latitude 43° southward to the Uinta Mountains, and from the Wind River Range westward to the Wyoming Range, is a broad valley, with a surface generally flat and unbroken, semi-desert in character, with a gravel or clay soil. Its length is about 140 miles, its mean breadth 75 miles, and its area about 10,000 square miles.

On the northwest the Basin rises to a rim, beyond which the country breaks off abruptly to a much lower level, forming the valley of Hoback's River, a large branch of the Snake. North of this valley rises the magnificent wall of the Gros Ventre Range, trending northwest and connecting the Wind River and Wyoming Ranges. The Wind River Range, trending north-northwest, limits the Basin on the east as far south as the South Pass. Beyond this range to the southward the Basin has no well-defined eastern limit, but merges gradually into the sterile plateaus which form the Continental Divide. On the south, the transverse range of the

Uintas forms the boundary, through which the Green River winds in deep gorges. The southern half of the western limit is as ill-defined as on the east, the land rising gradually to a plateau which separates the Green from the drainage of the Bear. Proceeding north, this plateau rises, becomes cut into long, narrow, meridional ridges, which I have named the "Absaroka Ridges," and which, farther north, are eroded into mountains, forming what is known as the Wyoming Range. At the east base of this range, the lip or rim of the basin is very strongly marked, sloping gradually down to the valley on the east and breaking off abruptly on the west, leaving a narrow meridional valley, crossed by numerous branches of the Green between the rim and the mountains. Within my district, the Green occupies a position several miles west of the middle line of the Basin.

In the upper part of the Basin, the Green receives numerous large branches. Most of the streams from the western slope of the Wind River Mountains collect into one large river, the New Fork, fordable with difficulty even at low stages of the water. This joins the main stream in latitude 42° 34′ 00″, longitude 109° 58′ 30″. The country in this upper part of the Basin is devoid of timber, but well grassed and watered. The soil, however, is gravelly, and the elevation is too great to allow it to be used for agriculture, or for a cattle range, except in summer.

From the Wyoming Range and the Absaroka Ridges, which may be considered as its southern extension, the Green receives numerous large branches, which, after tortuous courses through the mountain cañons, cut their way through the rim of the Basin and thence meander peacefully eastward to join the main stream. The principal of these western branches of the Green, commencing at the north, are Lead, Horse, Marsh, White Clay, Bitterroot, Piney, La Barge, Fontenelle, and Slate Creeks, and Ham's Fork. All these streams, with the sole exception of Slate Creek, carry considerable water throughout the year. Lead and White Clay Creeks are the only ones of these which do not reach the mountains, and they are the only ones of these western branches of the Green which, heading in the Basin rim, are constant runners. In July the former is about 6 feet in width, 6 inches in depth, and carries not more than 10 cubic feet of water per second. This creek enters the Green on the north line of my district. Above and below its mouth the Green is a rapid, clear stream, with a current of about 5 feet per second. On either side, the country stretches back in great level expanses but slightly raised above the river, occasionally varied by hill-masses. The soil is gravelly, with low sage and some grass. The river flows south for 6 miles, then turns east and hugs closely the base of a group of hills, the remains of a high bench, on the left. Near the foot of this eastern bend, Horse Creek joins it.

The country between Lead and Horse Creeks is mainly flat, but diversified to some extent by the remains of benches of a higher level.

Horse Creek is one of the largest of these western branches, carrying, in July, nearly 200 cubic feet of water per second, and fordable in high water with the greatest difficulty. It drains quite a large area of the Wyoming Range, collecting all its small affluents into two main branches in the valley behind the Basin rim; these two forks break through the rim, uniting in the basin several miles above the mouth of the creek. For four or five miles this stream and the Green flow side by side in the same broad bottom-land before uniting, forming one of the finest areas of meadow-land on the river. Here both streams are very sluggish and winding, with many sloughs, backwaters, chan-

nels, and islands. Two or three miles below the mouth of Horse Creek the river turns again to the south and its velocity increases. Throughout its course, as far as it has fallen under my observation in the Basin, an eastern or western course is accompanied by a marked decrease in velocity. It is bordered on the left-hand side, as far down as the mouth of Slate Creek, by a high bench 200 to 300 feet above the river, the normal level of the interior of the Basin. In most places the edge of this bench is bluff, sometimes precipitous, but in certain places presents easy slopes to the river. Throughout the greater part of the distance its edge is two or three miles back from the river, but in places the river flows close under its bluff wall.

As we go south from Horse Creek, the country becomes more undulating and hilly, with buttes, bluffs, &c., the remains, as above, of higher formations. It becomes, also, more forbidding in aspect. Patches of snow-white alkali diversify the yellow surface; the sage becomes more stunted, and cacti are seen more frequently. Marsh and White Clay Creeks flow through this country. The former stream carries about 100 cubic feet of water, which, near its mouth, is decidedly alkaline. It collects its tributaries behind the rim of the Basin, through which it forces its way. The latter stream heads in the basin-rim. It is a small stream, flowing in a deep arroyo cut in the stiff clay which here forms the soil. The water is thick and white with alkali, and utterly unfit to drink.

At the mouth of the New Fork the Green turns nearly west, flowing in this course for about seven miles, then turns abruptly to the south again. At this bend it receives the contributions of White Clay, Bitterroot, and Piney Creek. The last two are good-sized streams of clear, sweet water, each delivering about 100 cubic feet per second in July. They come from the Wyoming Range, and, like Marsh and Horse Creeks, collect their waters in the meridional valley back of the basin-rim. The country between and about them is much more uniform than farther north, and there is a decided decrease in the amount of alkali, accompanied by a change for the better in the character of the vegetation.

Below the mouth of Horse Creek, the Green is in a bottom-land from one to two miles in width, but narrowed in some places by the advance of the bluffs. This bottom is limited on the west by low bluffs, perhaps 50 feet in average height. Opposite the mouth of New Fork these bluffs increase in height until they rival those on the east side of the river, but almost immediately break away and disappear, and at the bend where the Bitterroot and Piney enter there are no bluffs whatever. The bottom-lands of the river contain no timber except cottonwood, which form an almost continuous belt of fine, large trees.

Following the river down, we find it preserving an almost southerly course, with broad bottoms containing magnificient groves of cottonwood and richly carpeted with grass. Between the Piney and the La Barge, a distance of 25½ miles, the only water entering the river is a wet-weather stream, known as Feather Creek. The country west of the river has become more broken. Great masses of plateau, with clean, sharp-cut edges appear, and back of them a long mountain ridge, trending south, and known as La Barge Mountain, becomes a prominent object in the landscape. It stands a few miles east of the Basin-rim and rises to an equal height with it. In its northern end heads Feather Creek, while past its southern end La Barge Creek flows, collecting the drainage of that part of the mountain.

La Barge and Fontenelle Creeks are considerable streams, the former carrying about 75, the latter about 50, cubic feet per second. They head in the Absaroka Ridges, which form the southern continuation of the

Wyoming Range. Nearly all of their upper branches flow southerly, in narrow valleys between these ridges, cutting across them in short, close cañons, and collecting against the basin-rim to force their way through it.

In its course across the basin, La Barge Creek, after passing La Barge Mountain, is bordered on the north by low, flat country, but on the south the land rises immediately into a plateau which separates it from Fontenelle Creek, and, extending down to Green River, breaks off in a bluff edge. This plateau, far from presenting a uniform surface, is cut into shreds by erosion. A small alkaline creek flows from it into the Green between La Barge and Fontenelle Creeks. The Green makes a short offset to the east just below the mouth of this small creek, and another at the mouth of the Fontenelle.

Fontenelle Creek is so named after one of the best known of the early fur-traders of this region. It flows in a narrow valley, bordered on either side by low bluffs, which rise to a plateau level, covered with sage, among which grass is sparingly distributed.

Slate Creek is a small alkaline stream much vexed by beaver dams. It rises just outside the basin-rim, cuts a cañon through it vastly out of proportion to its size, and thence flows east to the Green, on the top of the plateau, which here has become depressed to the general level of the drainage. Near its mouth Green River emerges from between the broken bluff walls in which it has been confined below the mouth of La Barge Creek, and, turning southeast, flows off to join the Big Sandy. Though confined above by bluff walls 200 to 300 feet in height, the river has broad and beautiful bottom-lands, green with grass and cottonwood groves, in this section, from the La Barge to Slate Creek. Below the latter the bluffs are low, and in places entirely wanting, while the river-bottom preserves its character of breadth and fertility to the south line of my district.

The country west of the river and south of Slate Creek is scarcely broken, except by dry water-courses and one or two long lines of low bluffs, until Ham's Fork is reached, on the south line of the area under consideration. This stream, which in high water is scarcely fordable, in the fall of the year dwindles to an insignificant creek. In its drainage area and length, however, it exceeds any of the other western branches of the Green which we have considered. It heads in and west of the meridional ridges, its main stream reaching behind and as far north as the sources of the Fontenelle. After flowing southward through a broad basin in the hills for many miles, it turns eastward; cuts its way out into the Green River Basin; there it flows nearly southeast, and finally, after a course of nearly 40 miles in the basin, it unites with Black's Fork, at Granger, a station on the Union Pacific Railroad.

The Big Sandy is the first stream to enter the Green from the east below the mouth of the New Fork, in a distance of 63 miles. It is at the mouth a large stream, fordable with difficulty at high water, and at a medium stage carrying about 200 cubic feet per second. It draws all its water from the Wind River Mountains, its farthest source being against the most southerly branches of the New Fork. The stream leaves the mountains as a full-grown river but a few miles south of Willow Creek, and immediately turns to the south, flowing down the east side of the valley quite close to the base of the mountains. For many miles it receives no tributaries of any importance from the east, and throughout its course none whatever from the west. Indeed, the only branch of any importance which it receives outside of the mountains is the Little Sandy, a small stream from the southern end of the Wind River Range.

The Big Sandy is of small importance in an economic point of view. Its waters can be used in irrigation only to a very limited extent, as it is in low rock cañon through a great part of its length, and its bottoms, where there are any, are very narrow.

The country south of the lower course of this stream and east of Green River is a desert without possibility of amelioration through human agencies. The soil is drifting sand, alkaline clay, baked smooth and hard, or loose, friable clay, produced by the disintegration of masses of "bad land." Water can by no possibility be brought to it.

Farther up the Big Sandy, the strip lying between the stream and the foothills of the Wind River Range shows in the natural state a decided improvement. Sage is the predominating growth, as everywhere, but some fine bunch-grass is to be found in it. There is, however, no possibility of irrigating it.

The great area lying between the Big Sandy and the Green, an area 30 miles in width and at least 60 in length, is entirely without water. Like the Great Plains, it is not perfectly level, but slightly rolling, rising and sinking in long swells. This is the plateau, or bench, which on the west edge breaks off in bluffs to the Green. This, also, as far as being of use to man is concerned, is a desert, as water cannot be economically brought up on its surface. Sage is everywhere abundant, but grass is very scarce. It may be fair to suppose that here the fugitive name "Great American Desert," after having been driven half way across the continent, has at last found a resting place.

THE WYOMING RANGE.

This range lies west of the northern part of the Green River Basin; southward, it runs out into long north and south ridges, which gradually decrease in elevation, merging into the plateau about the head of the "Muddies." It is limited on the west by the cañon-like valley of John Day's River, a large tributary of Snake River. Its length, considering its southern end to be at Thompson's Pass, is, within this district, about 35 miles, while its average breadth is about 8 miles. Most of the drainage of the range goes off to the eastward into Horse, Marsh, Bitterroot, and Piney Creeks, while on the west side, along most of its length, it presents a sheer continuous wall to the valley of John Day's River. Two tributaries of John Day's River, only, head up into the range to any great distance, the southern one, McDougal's Creek, heading in McDougal's Gap. The elevation of the peaks ranges from 10,000 to 11,000 feet, and the two highest peaks are respectively 11,276 and 11,490 feet above sea-level.

The principal passes in this range are Thompson's, at its southern end, at the head of the southern branch of the Piney, and McDougal's Gap, 25 miles farther north. There is a great difference in elevation between the east and west bases of the range, which at the latter pass amounts to 1,500 feet. This pass, or gap, is cut down very nearly to the eastern base of the range, so that the stream on the east, a branch of Marsh Creek, has very little fall, while, on the other hand, the ascent from the west is very steep, being 1,500 feet in about 8 miles, and the greater part of this is in the first two miles from the summit. The cañon of this creek is very narrow and difficult to traverse on account of swamps, fallen timber, and rock slides. A heavy trail, however, crosses the range here, and it is probably one of the main routes of the Shoshone and Bannack Indians. Farther north, an old trail crosses the range at a great elevation, but I was unable to examine the route throughout.

This range, with the Absaroka Ridges to the southward, is timbered from the base, though nowhere heavily. In the high valleys there is some large valuable timber, but the amount of this is limited. As we proceed southward the timber decreases, and the country about the upper waters of Slate Creek and Ham's Fork is almost destitute of it. These rolling hills and plateaus into which the Wyoming Range has degenerated are covered with the best of grass for pasturage.

JOHN DAY'S RIVER.

This stream heads near the southern ends of the Wyoming and Salt River Ranges and flows somewhat west of north to the Snake River. It is named from one of the early trappers of the region. Its valley is narrow and cañon-like throughout. At flood-height the stream is barely fordable, and carries fully 3,000 cubic feet per second. Its low-water flow is probably not more than one-third as much.

The valley, or, more properly, the slopes of the mountains contain a considerable quantity of excellent timber which can easily be transported by water to settlements on the Snake River.

THE SALT RIVER RANGE.

This range stands west of the valley of John Day's River, separating it from the Salt River Valley. It is a sparsely timbered, rugged range, not as high as the Wyoming Range by fully 1,000 feet. Its length within the district is about 30 miles, or about 40 miles altogether, as it is cut short on the north by the Snake River, which here passes by its northern end. Southward it runs out into meridional ridges part and and parcel of the southern continuation of the Wyoming Range. The latter, however, are drained southward by the head streams of Smith's Fork of Bear River.

Though this range can be crossed by animals in several places, there is but one pass in the range proper which is in common use—that known as McDougal's Pass. This McDougal, whose name figures so prominently in this part of the country, was another leading character in the days of the fur companies. This pass is quite high, leading one nearly to the top of the range, but is not difficult for pack animals. Early in the season, indeed, throughout July even, there is a great amount of snow in its approaches, especially on the western side of the summit. It is impossible to avoid it, and the only way is to travel across the great snow fields, doing so early in the morning before the sun has softened the surface. When I crossed this pass, which was on the 17th of July, there was, besides many large snow-banks east of the summit, one immense field just west of the head of the pass, completely filling the cañon and extending down it fully three miles. Of its depth one could form no idea, except that it must have been enormous. Whether it is a glacier could not be determined, as snow completely covered everything.

THE SALT RIVER VALLEY.

Salt River is an important southern branch of the Snake, entering it about three miles west of the mouth of John Day's River. It heads far to the south, opposite branches of Smith's and Thomas' Forks of Bear River, among bare, rolling hills. Collecting its branches at a point nearly west of the south end of the Salt River Mountains, it pursues a course nearly north down a broad valley, of which it occupies the western mar-

gin. In this valley it receives several large branches from the Salt River Range, and two, Crow and Smoking Creeks, from the hills which limit its valley on the west.

The valley has a length of forty-five miles, with an average width of about five miles. Its surface is flat and unbroken, except in one place, where there is a broad hill or bit of plateau which has forced the river into cañon. In several places near the river the valley is swampy, but generally it is dry, with a coarse, gravelly soil, of little value for agriculture. Grass is abundant and of excellent quality, and as a grazing region, especially in winter, I should judge it to be well adapted. On the west side of the valley the country rises sharply into plateau-like hills, well grassed. Further back these plateau-levels rise to a range of sparsely wooded hills, which separate the drainage of Salt River from that of the Blackfoot. To the southward these broken hills rise into mountains, of which Mount Preuss is the culminating point, and then again decrease in elevation towards Bear River.

THE BASIN OF THE BLACKFOOT.

This stream, a branch of the Snake, which it enters a few miles west of Fort Hall, pursues a curiously sinuous course. Heading in the hills opposite Smoking Creek, it flows at first nearly west, then turns to the south, and after flowing in this course for several miles, on meeting a northward-flowing branch, it compromises with it by turning again to the west. On this course, varied by occasional short turns to the south, it passes through a range of hills, a spur from the Mount Preuss group, and around the south margin of a valley called by some fanciful map-maker the "Hollow Hand," on the way receiving two large branches from the south. The second of these turns the main stream to its own direction, and a northward course is assumed, but, flowing against a basalt wall, the stream is forced to resume its western course. Then, on reaching a depression in the field of basalt, the stream crosses it to its northern edge, passing with sluggish current through great swamp areas. Reaching the hills on the north side of this basalt-field, outliers of the Blackfoot Range, it turns west again, then northwest, clearing the basalt and running in among the hills. Here we lose sight of this delectable stream, whose waters are now lukewarm and full of vegetable matter from their long stay in swampy regions.

The basin of this stream extends north to the north line of my district. On the east it is limited by the hills separating it from Salt River drainage; on the south, a range of high, sparsely-timbered hills divides it from the Bear River; while on the west the divide is somewhere in a broad field of basalt. The northern part of this basin is floored with basalt, out of which rise numerous ridges and buttes to a considerable height. The southern part is occupied by northward-trending spurs from the mountains, between which are broad valleys, in or across which flow streams tributary to the main river. The basalt region is characterized by great areas of swamps. John Day's Lake, just beyond the north line of my district, is the largest one of them. It is not, properly speaking, a lake, although there is, even in the dry season, quite a large body of standing water in the middle of the swamp. The Blackfoot flows through a very large swamp in crossing the basalt field, as was noticed above. The Little Blackfoot enters it in this swamp, and further up its course the latter stream passes through another large swamp.

The floor of the Blackfoot Basin, or the "Hollow Hand," has a very

uniform elevation, and the streams have very little fall throughout. The height of the basin ranges from 6,000 to 6,300 feet.

There is no timber in the basin, but sage and grass are abundant everywhere. The buttes and ridges that diversify the surface have some small quaking aspens on their sheltered slopes.

THE VALLEYS OF THE PORTNEUF AND MARSH CREEK.

Still travelling westward, we cross a great field of basalt, with here and there an extinct crater with its characteristic shape admirably preserved, and passing through a gap in a range of low, broken hills, the passage-way for a stream of lava, we enter another broad, flat valley—that on the upper course of the Portneuf. This stream, a large branch of the Snake, also pursues a tortuous course to effect a junction with the main river. Heading near the north line of my district, it flows nearly south for 36 miles, in the last 14 of which it gradually works its way into the Portneuf Range. Then it boldly turns west and carves a cañon for itself through the range and flows out into its lower valley. Here, in former times, it was joined by Marsh Creek, a long stream which drains the broad southward extension of this valley; but a stream of basalt which flowed through the cañon of the Portneuf entered the valley on the left-hand side of the river and separated the streams, and by filling up the bottom of the valley crowded them over on either side. For 10 miles below their former junction, these streams now flow apart, joining at the foot of the valley, where the Portneuf turns again to the west to effect a passage through the Bannack Range. This tongue of basalt which separates the streams is nowhere two miles in width, while its average breadth is only a mile. Judging from some of the older maps of this region, one might suppose that the flow of basalt which separated these streams was of very recent occurrence, indeed, within the present century.

The Portneuf passes the Bannack Range in a narrow cañon-like valley, then turns north-west, while the mountains recede on the right and left, and finally it reaches the Snake in the great basalt plain near the site of Old Fort Hall.

The upper valley of the Portneuf is one with that of the Bear, known as "Gentile Valley," the divide between the two streams being a broad, flat field of basalt. Along the Portneuf the valley is very fine for agricultural purposes, although the supply of water is very limited, the Portneuf here being scarcely worthy of being dignified with the name of river. Pasturage is excellent, both in the valley and in the hills on either side. The elevation is about 5,500 feet. Below the cañon there is little land valuable for agriculture, but on the benches and lower slopes of the mountains there is much fine grazing. Passing down the river past the Bannack Range, we enter a bay of the Snake River plains, and here we again find some arable land with excellent grazing over large areas of plains and hills.

The southern and broader part of the lower valley of the Portneuf is occupied by its main tributary, Marsh Creek, a sluggish, swampy stream, as its name indicates. This valley has a maximum width of 5 miles by a length of 12 miles from the head to the point where the Portneuf enters it. Its surface is floored with old lake deposits of gravel and finer material from the ancient Lake Bonneville, the progenitor of the Great Salt Lake of the present day. At its southern end this valley connects with Cache Valley by Red Rock Gap, a notch in the hills, whose level is not higher than that of the valleys on either hand. The gap is very nar-

row, affording passage only for a wagon road and the Utah and Northern Railroad, while a rock standing in the middle of the gap contracts the passage-way still more. The summit of the gap is on a great divide or water-parting—that between the Great Basin and the Columbia River; in other words, the Pacific; yet here the drainage of these two systems has a water connection, a marsh extending across the pass from Marsh Creek on the one side to Marsh Creek on the other. At its southern end, also, this valley of Marsh Creek is connected with the Malade Valley, in which is a large branch of Bear River, known as Malade, Reed, or Roseau River. The pass or divide connecting these valleys is much higher than that of Red Rock, being 5,690 feet above the sea.

Marsh Creek Valley has much fine farming land in the broad creek bottoms and at the bases of the ranges which border it on all sides. The supply of water for irrigation, however, is very limited, and will restrict the farming land to a small area. The whole valley, with the lower slopes of the surrounding mountains, may be classed as grazing land.

THE BANNACK RESERVATION.

The valley of Marsh Creek and the Lower Portneuf form a part of the reservation for the Bannack Indians. The limits of this reservation are thus defined by executive order of June 17, 1867: "Commencing on the south bank of Snake River, at the junction of the Portneuf River with the said Snake River; thence south 25 miles to the summit of the mountains dividing the waters of the Bear from those of Snake River; thence easterly along the summit of said range of mountains 70 miles to point where Sublette's road crosses said divide; thence north about 50 miles to Blackfoot River; thence down said stream to its junction with Snake River; thence down Snake River to the place of beginning." Owing to a want of even the most general geographical knowledge regarding this region, this order contains several impossible conditions. There is no mountain range trending eastward, separating the waters of the Snake from those of the Bear. All the ranges of the region trend north and south, and the divide in question follows no one of them any considerable distance. Moreover, the divide, which crosses valleys and ranges, though as a whole it makes easting, has in different places every course except west, nearly boxing the compass. Still, the meaning of the order is apparent, and the surveyor who ran the lines interpreted it rightly. He ran south from the mouth of the Portneuf to the crest of the divide; then, turning to the left, he followed it across valleys and ranges, through all its ramifications, until it reached Sublette's road, where he turned north and ran to the Blackfoot, completing it as the order reads.

DRAINAGE AREA OF BEAR RIVER.

Bear River heads in the northern slopes of the Uinta Mountains, and from their base flows nearly north. The Union Pacific Railroad crosses it at Evanston, Wyo., near the western line of the Territory. From Evanston it continues in its northerly course for about 65 miles, most of the distance being in a broad valley. It enters the district under consideration in this broad valley, flowing nearly on the surface, with little or no bluffs. Its current is very sluggish; the water consequently deep and the bottom soft and treacherous. Consequently, although it is not a large stream, fording places in this part are rare. On August 24 the stream was gauged in this valley, above the mouth of Smith's Fork, and found to carry but 112 cubic feet of water per second. It had been a

very dry season, and this is probably less than its usual capacity at this season. This valley is limited on the east by a range of high, bare hills, beyond which are the upper waters of Ham's Fork. On the west rises a mass of hills which separate the Bear from Bear Lake. The width of this valley is about 2 miles; its length within the district is 25 miles. This valley ranges in height from 6,200 to 6,500 feet above the sea. It is exposed, and the winters are rather severe. Still, several ranches have been settled in sheltered localities, and cattle graze over the hills or pick up a scanty sustenance among the sage and greasewood of the valley. At the foot of this valley Smith's Fork enters the river from the north. It drains the parallel ridges which run south from the Salt River Range. Its valley and those of its tributaries are narrow and of little value to the agriculturist. The Bear flows northwest for several miles after receiving Smith's Fork, hugging closely the base of the hills on the left, until, entering the valley of Thomas' Fork, it turns to a west course, and is joined by Thomas' Fork, a second large branch from the right. The valley of Thomas' Fork is one of the finest in the section, being 13 miles long by an average of 3 in width. The soil is very fertile and the valley well sheltered by mountain ranges on either side. The stream heads opposite Crow and Beaver Creeks, branches of Salt River. It also receives large branches from the Preuss Range and smaller streams from the range opposite. Below the junction with Thomas' Fork, the Bear pursues a winding, sinuous course through a narrow valley, in which it crosses a range of hills, the southern extension of the Preuss Range. This portion of its course contains some very fine bottom-land, which is rapidly being settled. From among these hills the river emerges into the valley of Bear Lake. This valley, lying on the east side of the Bear River Range, has a total length in a direction somewhat west of north of 70 miles, with a maximum width of 12 miles, and a mean width of about 6 miles. On the east the valley is bordered by the Preuss Range and the hills farther to the south, which separate this valley from that of the Upper Bear. On the south it is terminated abruptly by high, bare hills; on the north it closes in gradually, extending as far as the Soda Springs.

The southern part of the valley is occupied by Bear Lake, leaving but a narrow strip of valley land between its shore and the mountains on the east, south, and west. It is a beautiful sheet of water, nearly oval in shape, 19 miles long by 7 wide, with an area of 125 square miles, hemmed in closely on three sides by mountains, which, on the east, rise abruptly in cliffs from the water's edge. Several fine streams, rising in magnificent cold springs at the base of the mountains, supply the lake. On the east, south, and half of the west side, the shore is a beautifully clean gravel beach. The rest of the west shore is marshy. On the north a natural dam separates it from the "Lower Lake," a vast swamp which in high water becomes a lake with marshy shores, while at other times the only standing water is in its southeastern corner. The "dam" is a narrow strip of land, but a few yards in width, extending across the northern end of the lake. Two breaks in it allow the waters of Bear Lake to flow out.

Bear River flows through the swamps of the "Lower Lake," gradually sweeping around to a course nearly north, and flowing on the west side of the valley, close under the bluffs. In the swamp and farther down the valley it is joined by a number of fine streams from the Bear River Range, and by two from the Preuss Range. The river has increased in size very much. On August 17 it was measured at the Soda Springs, at the foot of this valley, and found to carry 1,000 cubic feet per second.

At the northern end of the Bear River Range the river turns abruptly from northwest to south, sweeping closely by the foot of the precipitous "Sheep Rock," and hugs the western base of the range, while the valley continues its former course to the north-northwest, becoming at first the broad flat divide between the Bear and the Blackfoot, and finally opening out into the great basalt plain in which the latter stream flows. The Soda Springs, called by Frémont the "Beer Springs," are on the north side of the Bear, very near the head of the bend. They are quite numerous, scattered over an area of several square miles; all are cold, except one. The water is highly charged with carbonic-acid gas, which is given off copiously. Many of them deposit carbonate of lime, forming mounds and coating rapidly whatever foreign matters are in the springs. A few miles above the bend the river enters a basalt field, coming down from the north and filling the whole valley. The river crosses this field twice before reaching the bend, and below the latter it is for several miles crowded by it up against the base of the mountains. Then it starts westward, on top of the basalt, whose surface is here somewhat lower than near the Soda Springs. In its westward course the river cuts down through the basalt, soon making for itself a cañon. Its fall in this part is very rapid indeed, covering its surface with foam. It is here in the southern continuation of the upper valley of the Portneuf, here known as Gentile Valley, the few settlers not being of the Mormon persuasion.

Having crossed the basalt to the western side of the valley, the river turns to the south, bordered on the right by the base of the Portneuf Range, on the left by a black precipitous wall of basalt. In a few miles it reaches the southern extremity of this field of volcanic rock, and enters what is more properly Gentile Valley—a fine, but narrow valley, fertile, and easily irrigated either from the Bear or from the numerous streams which descend from the mountains on either side. Below this valley the river flows through a cañon in a spur of the Bear River Range, by which the latter makes a low connection with the Portneuf Range. This cañon has a maximum depth of 1,200 feet, and is very narrow and rugged. Emerging from this, the river enters Cache Valley, the garden of Utah. This beautiful valley is surrounded by mountains on all sides. The Malade Range, a direct continuation of the Wahsatch, protects it from the west winds; the Portneuf Range comes to an end at its northern end, while on the east the rugged summits of the Bear River Range rise abruptly from the fertile plain. On the south, a high saddle connects the latter with the Wahsatch. The length of the valley in a north and south direction is about 50 miles, while its maximum breadth is 15 miles. Its area is 500 square miles. On the north, Red Rock Gap, between the Malade and Portneuf Ranges, affords easy access to the valley of Marsh Creek. Practicable routes to the northward lead to Soda Springs, and several passes over the Bear Biver Mountains give access to the valley of Bear Lake and the country beyond. A great depression in the Malade Range gives easy communication with Malade Valley and the settlements on the shores of Great Salt Lake, the latter of which are also reached by going out of the valley southward and then traversing the Wahsatch Range by the gap of Box Elder Creek, or the Ogden River. The valley is drained by the Bear River, which, entering it on the northwest, flows down near its middle line and makes an exit westward through the Malade Range, cutting a narrow notch, known as the "Gates," through the range at the point of depression mentioned above. The mountains send down numerous streams to water the valley and swell the volume of the river. Following down the east side of the valley, we first cross Mink Creek, a good-sized stream, carrying about 50

cubic feet of water, and flowing in a narrow valley bordered by bare, rolling hills. Next we come to Cub River, a stream which, where it enters the valley, is twice as large as the latter. This stream flows to the southward parallel to the Bear, keeping near the eastern edge of the valley for several miles, collecting the waters of several fine mountain streams, which it finally discharges into the Bear. Still going south, we cross a succession of branches of Cub River and the Bear. On the south line of my district, we reach Logan Fork, the largest tributary to the Bear within Cache Valley. This stream heads in the heart of the Bear River Mountains, collecting its waters from all directions, but mainly from the north. Entering the valley, it takes a wide sweep to the south and west, receiving the contributions of Blacksmith's Fork and Muddy River, the former from the Bear River Mountains, the latter from the Wahsatch Range, and joining the Bear a few miles above the Gates.

On the right-hand side of the valley the tributaries of the Bear are neither as large nor as numerous. Battle Creek heads in bare, rolling hills at the southern end of the Portneuf Range, and flows into the Bear a few miles below the foot of the cañon. It is a small stream, known chiefly from the fact that its mouth is the scene of a bloody battle between the California Volunteers, under General Connor, and a large body of Bannacks, in which the latter were nearly all sent to happy hunting grounds and the power of the tribe was broken. A mile below this point is the mouth of Deep Creek, which heads in the mountains about Red Rock Gap. Weston Creek, from the Malade Range, enters a few miles farther down, and, near the Gates, a small creek, from the same range, completes the branches from that side.

Cache Valley is very well settled, almost entirely by Mormons. There are no less than fifteen towns in the valley. On the west side of the valley, close to the base of the mountains, are Franklin, Richmond, Smithfield, Hyde Park, Logan, Providence, Millville, Hyrum, and Paradise, while on the west side of the valley are Oxford, Clifton, Newton, Clarkson, Mendon, and Wellville.

The principal, indeed, almost the only occupation of these people is farming. The farms extend from the towns down towards the middle of the valley. The land in the lower parts of the valley, towards the river, is marshy in spring and early summer, making irrigation unnecessary.

All kinds of cereals, all vegetables known to a temperate climate, and, what is rare in the West, many fruits, are among the products of this valley. Apples of fine quality are raised in the greatest abundance, and many varieties of plums. Peaches are cultivated to some extent, but not with as great success as in the Salt Lake Valley, where their production is one of the chief industries of the farmers.

Emerging from the narrow gap of the Gates, the Bear enters the large valley of the Malade. This lies west of Cache Valley, and, like it, trends nearly north and south. It has a length of 50 miles and a mean breadth of 3 or 4 miles.

The valley of the Malade completes the lowlands of the Bear River drainage. The Malade, formerly known as the Reed or Roseau River, derives its present name from the fact that its water is unfit to drink, by reason, probably, of the large amount of decaying vegetable matter which, in its sluggish course, it receives and holds in suspension.

The most northern branch of the Malade, known as the Little Malade, heads far to the northwest, opposite the head of Bannack Creek and in the valley west of that of Marsh Creek. The main body of water of the Malade River proper comes from an immense spring in the northwest

part of its valley. Other streams, bringing considerable bodies of water, head in the mountains about the Malade Divide and in the western slopes of the Malade Range. Collecting just below Malade City, these streams form a good-sized river, which flows from the middle of the valley with a sluggish course and a bed slightly depressed below the level of the valley. After reaching the neighborhood of the Bear, it flows along parallel and very near to it for several miles, joining it but a short distance above where it enters Great Salt Lake.

Malade Valley is a fine, fertile valley, settled almost entirely by Mormons, who have built several towns within it. Among them are Malade City, Samaria, Portage, and Plymouth. As elsewhere throughout the Mormon settlements, agriculture is the principal occupation of the people.

Leaving now the valleys of this western section, we will take a glance at the mountain ranges which separate them. In them all we notice a remarkable absence of timber. With the exception of the Bear River Range, which contains a large amount of excellent timber, they are almost without this kind of vegetation. On some it is found scattered over certain areas, but not in large quantity, and in quality and size it is inferior. The lower slopes and foothills of the mountains are everywhere bare of trees, being covered with sage and grass.

The Portneuf Range extends southward from latitude 43° to the north end of Cache Valley, trending almost on a meridian. It is a broken, irregular range, varying greatly in height and breadth. Midway of its length it is cut through by the Portneuf in its passage from its upper to its lower valley. On the east of the range is the upper valley of the Portneuf, with the valley-divide between this stream and the Bear and Gentile Valley. On the west is Marsh Creek Valley.

This range commences on the north with Mount Putnam, rising abruptly from the valley of Ross Fork, a branch of the Portneuf. The height of this peak, one of the highest of the range, is 8,933 feet. A broad summit 4 or 5 miles to the east, distinguished as Station 74, has a nearly equal height. Then follows southward a long and very considerable depression, followed by a rise, culminating in a group of peaks of which Station 76, 9,115 feet, is the highest. Then the range breaks down to afford passage to the Portneuf. South of this gap the range is more complex. Snow Mountain, 9,269 feet, is the highest summit in the southern section, and is a centre whence several spurs set off to the north and south. Farther to the south the range spreads out in a broad area of low, rolling, bare hills, which limit Cache Valley on the north.

West of Marsh Creek Valley is a high, abrupt range, for which I propose the name of the "Bannack" Range. It is in two sections, connected by a long, low depression opposite the middle portion of the Marsh Creek Valley. The northern section consists mainly of two long mountain ridges, the highest points of which were occupied as Stations 77 and 78 respectively.

The southern section rises from the Malade Divide, and southward it extends some distance into the Malade Valley. Its summit consists of a rugged ridge rising considerably at each end. The northern summit was occupied as Station 135. Its height is 8,931 feet, while the height of the southern summit is 9,220 feet.

Turning now to the ranges separating parts of the sinuous course of the Bear, we meet first the mass of hills lying between the upper valley of the Bear and that of Bear Lake. Northward we find a high mountain mass, which I have called the Preuss Range, the central figure of

which is Mount Preuss. From this mass several spurs, of much lower elevation, put out. One heavy spur runs northward, connecting with Caribou Mountain, a few miles north of my district, and separating the Blackfoot from Salt River. Another trends northwest and divides the Bear from the Blackfoot, while a third goes south and separates the valley of Thomas' Fork from the Bear, below Bear Lake. This spur, greatly decreased in altitude, is cut through by the Bear, below the mouth of Thomas' Fork, in its passage from its upper valley to that of Bear Lake. South of this cañon the hills rise again to a considerable elevation, and broaden out, forming the divide between Bear Lake and the upper valley of the Bear. In their highest part, a few miles south of the Bear River, these hills reach altitudes of nearly 8,000 feet. Thence southward, they diminish in elevation and in detail, degenerating into a broad plateau.

While in this neighborhood, mention must be made of a short range of high mountains which separate Smith's and Thomas' Forks of the Bear. At its south end this range rises abruptly from the former stream near its mouth. The range increases in height by successive steps, one bare, round summit rising above another until the highest crest, Station 38, is reached, at an altitude of 9,223 feet. Then follows a precipitous notch, cut clear down to the level of Thomas' Fork by a stream which heads in the east face of the range. Beyond, the range consists of a close cluster of peaks, having very nearly the same height as Station 38; then a gentle and uniform slope of the ridge for several miles, followed by a precipice of several hundred feet, brings us down to the level of a branch of Thomas' Fork, at the north end of this range.

THE BEAR RIVER RANGE.

This range separates Bear Lake Valley on the east from Cache and Gentile Valleys on the west. It is a broad range, especially in its southern part, where it becomes quite complex in its structure. It is quite heavily timbered, except on the lower slopes, with coniferæ, while below their limit quaking aspen forms beautiful groves.

The north end of the range is at the northern bend of the Bear, near the Soda Springs, where the river flows around the precipitous "Sheep Rock." Soda Peak, a round-topped summit 9,683 feet high, is the culminating peak of the northern part of the range. From it the crest runs westward two or three miles, then turns north, and, gradually falling, ends at Sheep Rock. Eastward from Soda Peak, heavy plateau-like masses, much lower than the peak, extend eastward towards the Bear River. The crest runs nearly south from the mountain, gradually decreasing in height until North Pass, the lowest point of this great depression in the range, is reached. Thence it rises from summit to summit and gradually becomes broader, the streams at first flowing from the eastern part of the range westward. Here the range has in general outline the form of a plateau, broad on top, with steep, in some places precipitous slopes, particularly on the west. Paris Peak, 9,522 feet high, is situated on the eastern edge of the range. Beyond this dominating summit the eastern-bound streams drain to the western border of the range, while the latter presents a sheer wall to the west. Still going southward, the range rapidly becomes broader and is divided into several north and south ridges by tributaries of the Bear. We distinguish, first, on the west or Cache Valley side, a high, extremely rugged range, the highest of the series, rising abruptly from the smooth level of the valley. The dip of the rocks is toward the east, so that they present the

edges of the upturned strata to the valley. Climbing these mountains from the west is difficult and dangerous, while from the east, the slope being on the dip of the strata, the slopes, though steep (25° to 30°), are smooth and none of the ruggedness of the west side appears. Stations 121 and 123 (Logan Peak) are among the highest of this wilderness of peaks, being respectively 9,905 and 10,004 feet above sea-level. West of this ridge are the cañon valleys of Cub River, flowing north, and of Logan Fork, flowing south, separated by a high saddle.

East of the cañon of Cub River, the range rises again, with Station 113 as its highest summit in this part. Beyond, the drainage is eastward to Bear Lake. Southward from Station 113 its ridge degenerates into lower, heavily-wooded spurs, separating the cañons of large branches of Logan Fork, which here drains the range eastward to the extreme eastern ridge. This, and the rugged western range, become the highest ridges, leaving a basin of heavy-timbered ridges and spurs between them. This character holds to the south line of my district.

Logan Fork cuts its way through the western range to Cache Valley on my southern line, making a tremendous gorge, 3,000 to 4,000 feet in depth, very rugged, and sharply cut. Altogether, it is one of the finest mountain cañons in the West.

THE MALADE RANGE.

This is the direct continuation of the Wahsatch, though separated from it by a very long, low depression about the Gates of the Bear. It lies on the west side of Cache Valley, separating it from that of the Malade. It is characterized by two culminating groups of peaks, near its northern and southern ends, connected by a broad mass of hills or low mountains. Station 132, the culminating point of the northern group, has an elevation of 9,332 feet; while the highest point of the southern group, Gunsight Mountain, occupied as Station 127, is 8,306 feet above sea.

On the west side of the Malade Valley stands a mass of bare, grassy hills, separating it from the valley of Blue Spring Creek.

CHAPTER IV.

ARABLE, PASTURE AND TIMBERED AREAS.

The area of that part of the Green River Basin comprised within the rectangle under consideration is 4,300 square miles. In the latter part of June, near the time of spring floods, the river was gauged at Robinson's Ferry, about five miles below the mouth of the Big Sandy, and found to carry 13,620 cubic feet per second. From the marks of the highest floods upon its banks, it was estimated that the highest floods carry down 18,500 cubic feet per second. At its medium stage its flow is not more than one-half that at the time of gauging, *i. e.*, 7,000 cubic feet per second. This is much more than can ever be utilized for irrigation in the basin. The northern part of the basin is too high ever to be of much value for agricultural purposes. Farther down, the amount of land which can be reached by water from the river is somewhat limited. On the east, the high bluff wall which follows the river cannot profitably be surmounted by ditches; so that the immense area between the Green and Big Sandy must forever remain as it is, a sage-brush desert. It is only for a few miles above the mouth of the Big Sandy that water can be brought to any part of this great area.

The bottom-lands of the Green can everywhere be easily irrigated. These range in width from a half-mile to two miles. Besides these the bench on the west side of the river can be reached by water in certain localities and considerable areas irrigated, but the main source of water for irrigation must come from the side streams from the west. Most of these flow on or near the surface of the plain, and water can be carried laterally to some distance, covering areas which, in most cases, will be sufficient to absorb all the water of the streams. Such is the case with Marsh, Bitterroot, Piney, and probably La Barge Creeks. The Fontenelle is enclosed by bluffs, which limit its irrigable area to a strip only about a mile in width.

Below the mouth of Slate Creek, the Green flows nearly on the surface of the plain, with bluffs comparatively low, and a large extent of land on the right as well as on the left can be reached by ditches.

The Big Sandy flows for most of its course in low rock cañon, and the amount of its irrigable land is small. Although it is very difficult to set the limit of irrigation in this basin, still it is safe to say that not more than 700 square miles of valuable land can be reached by water. This area will necessarily include the best part of the pasturage of the basin, that in the bottom-lands of the streams, leaving only the scattering grass among the sage, which in most localities is *very* scattering, improving, however, in the northern part and near the western rim with the greater altitude.

On Ham's Fork, near its head, is an area of perhaps 50 square miles, which can be rendered productive.

On John Day's River there is no arable land. Salt River Valley is about 25 miles long, with an average width of 4 miles. Most of this can be irrigated, but the soil of the middle part of the valley only is of

value, as near the mountains it is gravelly. Narrow strips of valuable land extend up Smoking, Crow, and Beaver Creeks for several miles.

In the valleys of the Blackfoot and its branches there is much valuable land—more than there is water for. The upper valley of the river, and the valleys in which the South Fork flows and which it crosses, can be made productive. So with a large part of the valley of the Little Blackfoot. On the main stream little can be irrigated of the basalt field beyond the bottom-lands, as the basalt is rent by huge crevices in this direction and that, like a field of old ice. Altogether, probably 175 square miles of the Blackfoot Basin can be made productive.

The upper valley of the Portneuf contains much more flat land than the supply of water will irrigate, as the stream is here very small. A narrow strip of valley extends down the river through most of the cañon, widening out and running up the lateral branches. In the lower valley, Marsh Creek will water a narrow strip of bottom-land, averaging from one to two miles in width throughout its entire course. In this valley the Portneuf is crowded between a basalt wall and the steep slopes of the Portneuf Range, leaving no valley of any consequence. A narrow ribbon of bottom-land accompanies this river through the cañon below, in the Bannack Range, and as the valley widens out to the Snake River Plains the area of irrigable land becomes broader. The arable area on the Portneuf and Marsh Creek I estimate at about 150 square miles.

Turning now to the Bear River, we find in its upper valley a broad area susceptible of irrigation. The soil here is good, but the situation is exposed, and the winters long and severe. In the valley of Upper Twin Creek there are small areas of irrigable land. In this upper valley, altogether, there are about 150 square miles which can be rendered productive. On Smith's Fork there is a narrow valley, not more than half a mile in width and 20 miles in length. Thomas Fork has a very fine valley four or five miles in width and 15 in length, all of which can be irrigated. On the Bear, below this stream, in the cañon through the foot-hills of the Aspen Range, there are several square miles of fine bottom land, admirably well sheltered.

Bear Lake Valley contains about 275 square miles of tillable land. It extends in a broad belt on both sides of the river southward from the Soda Springs for 15 miles, then is interrupted by a mass of buttes which force the river into a cañon, but begins again at Georgetown and extends up to the lake. A large valley of excellent land extends several miles up North Creek. A narrow strip of arable land extends, with slight interruptions, up the west side of the lake. At its south end the valley widens out, giving an area of about 15 square miles of fine land, in which are the Mormon towns of Meadowville and Laketown. On the east side of the lake, the only flat country consists of small patches at the mouths of Indian and North and South Eden Creeks.

Following the Bear down below Sheep Rock, we find a small, irrigable area against the west base of the Bear River Range. Then, as the river runs out of the basalt, its course widens from a close cañon to a valley, narrow at first, but widening to a mile or more in Gentile Valley, which extends down to the mouth of Cottonwood Creek.

The lower part of Mink Creek has a few square miles of arable land. Then we reach Cache Valley, almost the whole extent of which can be cultivated, as well as the valleys of many streams entering it from the north and west. The whole area of arable land here is about 400 square miles. Much of this is naturally irrigated; while Cub River and Logan Fork, with their branches from the mountains and the other mountain streams, will go far towards irrigating the upper portion of the eastern half

of the valley. The western portion north of the Gates is slightly raised above the eastern portion, so that here the waters of the Bear cannot be used, and only such portions can be utilized as the numerous small streams and springs will water.

Malade Valley contains 175 square miles of irrigable land. The valley is flat, and though the streams have but slight fall, still, as the benches are everywhere low, the water can be taken all over the valley.

Summing up, I should estimate that this district contains 2,200 square miles of land that can be irrigated and cultivated profitably. It is one of the best agricultural sections of the Western country. This arable area is 17 per cent. of the total area of the section.

The following table represents in brief the absolute and relative areas respectively of arable, pasture, timber, and worthless lands.

	Area, square miles.	Percentage.
Arable land	2, 200	17
Pasture-land (where sage is not the predominating growth)	5, 300	41
Sage-land. (This may produce grass, but not in sufficient abundance to be classed as pasture-land.)	2, 500	19
Heavily-timbered land (timber, pine and spruce of large growth)	2, 000	15. 5
Area covered with scattering timber of small size or inferior quality	800	6
Lake area (Bear Lake and swamp)	200	1. 5

SETTLEMENTS.

In the march of emigration towards the setting sun, the drainage area of the Green River has been most carefully avoided. This has surprised me not a little. Although the Green River country, as a whole, is not the most delightful place of residence in the world, still there are many fine bits of bottom-land and of bench where the grazing is excellent; spots which, had they been in Colorado, would long ago have been seized by the squatter. Within that part of the basin which it fell to my lot to survey I can recall but half a dozen ranches. Of these, one derives its principal revenue from the ferry over the Green; another, at the upper stage-crossing of the Big Sandy, is a stage station; a third is a very large dairy ranch, located on the Green, at the mouth of Fontenelle Creek. Besides these there are two or three cattle ranches on the Green and La Barge Creek.

In the summer large herds of cattle are ranched in the northern part of the basin, but are driven out of the country southward before the snows of winter set in.

On Smoking Creek, a branch of Salt River, there is a small settlement whose inhabitants are engaged in manufacturing salt from the fine springs in that neighborhood.

On the Blackfoot there are two or three ranches only. On the other hand, the region of the Bear, Malade, Marsh Creek, and Portneuf is well settled. The valleys of Bear Lake, Cache, and the Malade already support a very considerable population, mostly belonging to the Church of Latter Day Saints. The upper valley of the Bear is mainly in Wyoming; so Mormons have not settled there, and, as the climate is rather severe for agriculture, few "Gentiles" have deemed it worth while to squat there while there is better land to be had for the asking.

Near the mouth of Smith's Fork, there are several fine ranches, besides two small centers of population, one of them known as Coketown. From this point down to its mouth there are ranches at short

intervals all along the Bear. The settlements (towns, villages, &c.), of which there are many in the Bear River country, are in all cases placed back from the river, generally at the edge of the valley, under the mountains, on some lateral branch of the main stream.

Around Bear Lake there are several fine little towns. At its head, in a beautiful valley, shut in on the east, south, and west by high, abrupt hills, are Laketown and Meadowville, staid little Mormon villages, having an almost Puritanic air of quiet and order. The population of the former, by the census of 1870, was 127, but since it has more than doubled. The latter contains nearly 200 souls.

Half-way down the lake on the west side is the little hamlet of Fishhaven, which in 1870 contained 52 persons. Since then it has grown but little, if any.

At the northwest corner of the lake is the town of Saint Charles, which in 1870 had a population of 294, now increased to between 300 and 400. Thence northward along the east base of the Bear River Range there is a series of small towns: Bloomington, with 316; Paris, with 502; Ovid, with 66; and lastly, at the forks of North Creek, Liberty, with 86 persons. These figures are from the census of 1870. The populations of these towns are now slightly increased.

On the opposite side of the Bear River Swamp, under the eastern wall of the valley, are the little towns of Bennington and Montpelier, with populations respectively of 57 and 299 in 1870, and probably little, if any, larger at present.

Farther down the valley, on Twin Creek, east of the river, is a good-sized village, by name Georgetown, containing about 200 people.

Then follows a long stretch of valley almost without inhabitants, reaching to the bend of the Bear at Sheep Rock. Here, on the north side of the river, are two little villages, Soda Springs and Morristown; the latter settled by the Morrisites, a band of dissenters from the Mormon Church. These two villages contain a total population of about 200 persons.

Farther down the river is Gentile Valley, which contains a number of fine ranches owned by unbelievers, whence the name of the valley. Below this the river flows out into Cache Valley, the "Garden of Utah." This fine valley contains altogether fifteen settlements, large and small. They are situated at the base of the mountains on either side of the valley; those on the east side being the largest and the most numerous. From the towns the cultivated fields stretch down towards the middle of the valley to the marshy land which borders the river. The fields are watered mainly from the lateral streams from the mountains. The towns, instead of the fields, are fenced. Ingress and egress is afforded by gates, which, during the growing season, are kept closed, and are opened by order of the resident bishop only when all the crops are gathered. Then the fields become common pasturage ground for the flocks and herds of the inhabitants throughout the winter.

On the east side of the valley, the most northern town is Franklin, Idaho, mainly peopled by Gentiles. This town is a product of the Utah and Northern Railroad, which, coming up from Ogden, passes through this valley on its way to Montana. The town is situated on Cub River, a large branch of the Bear, from the Bear River Range. In 1870, it had a population of 558. At present it is probably less. The boundary line of Utah is about a mile south of the railroad station in Franklin. Then follow, going south, Richmond, population 817; Smithfield, 744; Hyde Park, 343; and Logan, 1,757. These figures, given by the last census, have not been materially changed. The latter place is a beau-

tiful town, regularly laid out, with broad streets, business squares, with many brick and stone buildings.

On the opposite side of the valley are, near its head, Oxford and Clifton, situated respectively at the head and foot of Round Valley Marsh. The former has about 260, the latter 200 inhabitants. Farther south, a few miles northeast of the Gates of the Bear, are Clarkston and Newton, containing respectively 153 and 195 persons in 1870, and probably about the same at present. The remaining towns in the valley are outside of my district, and will not be mentioned in this connection.

In Malade Valley there are four settlements. Malade City, the largest place, is situated on Mill Creek, about 6 miles above its junction with Malade River. It had a population in 1870 of 591, and has increased little, if any, since. Samaria is situated southwest of the latter, 8 or 10 miles away, on the southwest edge of the upper expansion of the valley. Its population is between 100 and 200. Portage and Plymouth are two small villages, situated further down the valley, the one on the west, the other on the east side of the river. The total population of the valley is about 1,000.

In the valley of Marsh Creek and the Portneuf, the railroad has given birth to two paper towns—Oneida in the former and Portneuf in the latter valley. The latter town, which (1878) has just sprung into being, occupies a position at the present end of the railroad, about 3 or 4 miles below the mouth of Marsh Creek. These towns contain 200 or 300 people each, but it is a floating population dependent upon the railroad, and they may be suddenly deserted as the end of the railroad is moved northward toward the plains of Snake River.

RAILROADS.

The Utah and Northern is the only railway in my district. It is a narrow-gauge, built originally only to Franklin, by the Mormons, to connect their settlements. Starting from Ogden, Utah, where connection is made with the Union and Central Pacific and the Utah Central, it skirts the west base of the Wahsatch Range to its northern end nearly to the Gates of the Bear. Here it turns eastward, climbs the rolling plateau at the north end of the Wahsatch, and runs down into Cache Valley. Crossing this to the west side, it again turns north under the west base of the Bear River Range. It passes through the towns of Logan, Hyde Park, Smithfield, Richmond, and Franklin. Here for several years was the terminus, although it had been the original intention to push it on to Soda Springs, and a road-bed was graded for several miles in that direction. During the last year it got into the hands of Gentiles, and it was pushed northwestward through Red Rock Gap to Marsh Creek, and thence down the Portneuf, Montana-wards. Trains are now (1878) running to Portneuf station, on the lower Portneuf, and the road is graded nearly or quite to the Snake River.

HISTORY OF THE EARLY EXPLORATIONS OF THIS REGION.

From very early times, even back in the last century, this region has been frequented by fur traders and trappers. The waters of the Green, Bear, and Snake yielded valuable peltries in great abundance, and in the broad valleys the fur companies had their annual meetings with the trappers for trade. Naturally, here, too, took place many and bloody conflicts between the red men, the lords of the soil, and the interloping trappers.

The agents of the fur companies and the trappers, of course, became intimately acquainted with the country, but their knowledge died with them, and it was not until the year 1832 that anything like exploration was attempted. In that year Captain Bonneville, of the United States Army, having obtained a year's leave of absence, set out on a trading and exploring expedition. His venture was a private one, and his explorations were made at his own expense. Starting from Fort Osage, Missouri, he took the North Platte and Sweetwater route, crossing at South Pass to the Green River Basin. He took wagons as far as Horse Creek, on Green River, being the first to reach Pacific waters with them. He spent three years wandering about in the northwest country exploring, trading, and trapping. His travels extended to the Columbia River, in Oregon, in a northwest direction, and nearly to the mouth of the Big Horn, towards the northeast, and his map represents, with an approach to general correctness, the northern part of the Great Basin, portions of California, most of Snake River, the North Platte, Big Horn, Yellowstone, and Missouri Rivers, with the country adjacent to them. The principal geographical features of my district, the Green, Bear, Blackfoot, and Portneuf Rivers, are recognized. The map, however, is extremely faulty in geographical positions, many of them being one, two, or more degrees out of place. Bonneville was unquestionably the first to give the world definite, certain information regarding the Great Basin. Previous to his time all that was known of it was vague and visionary, the exaggerated tales of mountaineers and trappers.

Following Bonneville, in 1842, came Frémont. On his first expedition he crossed South Pass, and, skirting the southwest base of the Wind River Range, he went to the head of Green River Basin. Here, leaving his main party camped at one of the beautiful glacial lakelets which are found at the base of the range, he, after much toil and trouble, succeeded in reaching the summit of one of the highest peaks of the range, which has thenceforth borne his name. Having accomplished this, which in those early days was accounted a remarkable feat, he returned to the States. On his second expedition, he crossed the continental watershed at South Pass, and thence followed the present overland road down the Big Sandy to the Green, and thence, in a southerly direction, to Fort Bridger. Thence he went northwesterly, to Ham's Fork ("Muddy"), and from a point near its head, probably on the course of the overland road, he descended to the Bear. He followed the Bear to the Soda Springs, in Southeastern Idaho, continued down it through Cache Valley, and finally reached the shores of Great Salt Lake. He made a partial reconnaissance of the lake, in an India-rubber boat brought for the purpose; but, provisions becoming scanty, he beat a hasty retreat northward, to (old) Fort Hall, via the valley of the Malade (Roseau or Reed River) and the Portneuf. Thence he continued his route down the Snake towards Oregon.

Frémont was, on both these expeditions, well provided with instruments, and his work is generally regarded as among the best done in those early days. While the errors of some of his positions are great, still they are no larger than was to be expected from the methods necessarily employed.

In 1849, Captain Stansbury, during the progress of his survey of the Great Salt Lake, made two reconnaissances within the district under consideration, one northward, up the Malade and down the Portneuf to (old) Fort Hall, on the Snake river, near the mouth of the Portneuf, and the other up the Bear into Cache Valley.

In 1857 and 1858, extensive explorations were made in this region for

the purpose of locating routes for wagon-roads from South Pass westward. These were made by the Interior Department and were in charge of Mr. F. W. Lander. By combining the topographical work of the different parties engaged, a map, on a scale of nine miles to one inch, of the area here treated of was made. This map, though containing many grave errors in position, was by far the best and most detailed map of any considerable area in the West at that time.

In 1873, Capt. W. A. Jones led a reconnaissance up the Big Sandy, on his way to the Yellowstone National Park, without, however, adding anything to our knowledge of the section of country under consideration.

In 1871, the boundary line between Utah and Idaho was run, establishing with some exactness the parallel of 42°. I was fortunate enough to be enabled to make trigonometric connection with the corner post as established by this survey to indicate the northeast corner of Utah and the southeast corner of Idaho. Relative to my own work, the corner stands 0.78 miles too far east, while in latitude it is practically correct.

The west boundary of Wyoming was run in the summer of 1873. I succeeded in connecting a stake on this boundary with our geodetic work and found the discrepancy to be but 0.16 miles, or 845 feet, which was entirely in longitude. This stake was a few miles south of the Utah-Idaho corner.

INDEX.